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ERRATA

Page 4, line 1 from top, “self employing” should read “self-employing”.
Page 11, line 14 from top, “males” should read “male”.
Page 34, line 5 from top, “The cost of producing the first liter is 1:9.6”, should read “The cost of producing an 80-kgm. boar is 1:8.5”.
Page 49, line 7 from top, “all around” should read “all-around”.
Page 66, line 4 from top, “self study” should read “self-study”.
Page 81, line 11 from top, “11.30” should read “11:30”.
Page 84, lines 14 and 15 from bottom, “If hemoglobin is affected by the nervous system, Mathews (1925)” should read “If hemoglobin is affected by the nervous system (Mathews, 1925)”.
Page 102, line 12 from bottom, “0.005” should read “0.005″” and “0.007” should read “0.007″”.
Page 118, table 4, third column, last figure, “226” should read “266”.
Page 134, lines 8 and 9 from top, “volcanic volcanic ash” should read “volcanic ash”.
Page 214, line 4 from bottom, “5.10” should read “5:10”.
Page 273, line 15 from top, “tweny” should read “twenty”.
Page 313, line 8 from bottom, “curly” should read “non-variegated”.
Page 411, footnote, 1, “An analysis of the report of the Joint Preparatory Committee on Philippine Affairs” should read “An analysis of the report of the Joint Preparatory Committee on Philippine ‘Affairs’ ”.
Page 419, line 17 from top, “New Work” should read “New York”.
Page 424, explanation of chart 5, “scrape tobacco” should read “scrap tobacco”.
Page 430, line 9 from top, “bottons” should read “buttons”.
Page 447, line 17 from bottom, “241” should read “2.41”.
Page 499, table 2, column 4, “veriation” should read “variation”.
Page 603, line 12, from top, “stme” should read “same”.
Page 688, line 13 from top, “sandy clay loam” should read “sandy clay”.
Cover page, table of contents, January issue, page “657” should read page “656”; “682” should read “681”; “693” should read “692”.
Page 779, 2nd paragraph, first sentence, “hall” should read “ball”.
Page 789, line 3 from top, “By N. B. Mendicla” should read “N. B. Mendiola”.
Page 807, line 7 from top, period after “NH_4-ion” should be omitted.
Page 814, footnote c, table 5, “$CaHPO_2.2H_2O$” should read “$CaHPO_4.2H_2O$”.
Page 858, experiment station contribution No. 1308, “Capinpin, I. M.” should read “Capinpin, J. M.”
Page 858, experiment station contribution No. 1309, a comma should be inserted after Miguel.
Page 863, general contribution No. 706, “1938” should read “1939”.
Page 863, general contribution No. 707, “Palanan” should read “Palauan”.

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INDUSTRIALIZATION AND PHILIPPINE ECONOMY [1]

MANUEL L. ROXAS
Of the National Development Company

While it is true that the government has an extensive industrialization program, still Philippine economy will remain largely agricultural. The conditions of the world today will not allow us to develop extensively along industrial lines in the way that *Occidental* countries and Japan have done. We must adopt a "middle course economy", remain largely agricultural with some industries developed along those lines, the products of which will find ready market at home and will not need tariff protection because they can be produced more economically here. This is no time to launch ourselves upon enterprises that will place us in direct competition with Occidental products in the world market. The new industries will require government support at the beginning before they can be placed on profitable bases. Although it has been stated that those industries that the government will subsidize because "they would be relatively inefficient at the time of their introduction, but give promise of so improving efficiency within a brief period as to be able to carry on operations without the continuance of the subsidy, rarely fulfill their promise", there are certain "must" industries that the government should foster for the benefit of the people.

The government can not be indifferent to the serious problem of malnutrition among the mass of our population. We can not gainsay the findings of science which point to the prevalence of certain deficiency diseases traceable to faulty diet brought about by undesirable social and economic conditions. In planning our future development, we can not lose sight of these facts. Therefore, a primary object of our industrial development must be our food industries. The government can do a great deal in placing within the reach of our common people an ample supply of supplementary foodstuffs in the form of cheap canned products. We may preach the gospel of hard work to the people; we may tell them that unless they work more, progress

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[1] Miscellaneous contribution No. 22. Address delivered at the commencement exercises, U. P. Rural High School, March 31, 1939.

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is not possible; but if they remain undernourished through lack of protective foods as a result of a faulty economy of production which is beyond anybody's power singly to remedy, I am positive that our preachings will be of no avail. We have for many years paid almost exclusive attention to the raising of export crops and have left the mass of our population to depend for their protective foods on expensive imported materials. The government through its agencies should foster the production of these accessory foods, promote the dairy industry, encourage the planting of fruits and vegetables, and through centralized and home canning, preserve the products of the season of plenty against the needs of the season of scarcity. It behooves our graduates of farm schools and agricultural colleges to play an important rôle in this development, the most important undertaking of the nation if we are to have a sturdy and prosperous race.

In the present development of our economy we do not and can not have enough industries to give employment to the thousands of graduates of our technical schools and colleges. The majority of these graduates should find their means of livelihood on the farm. The work of feeding the nation, I repeat, is the most important task that should confront our farmers of today. True it is that after the gay life in school, life on the farm may appear drab and lonesome to many a graduate, yet it is far better than living in the city where it is hard to seek employment. Unemployment in industrial centers has become very acute. At the National Development Company, for instance, more than 22,000 applications have been received for different positions, for a possible placement of only six to eight hundred, whereas we have hundreds of thousands of hectares of idle land awaiting the hands of pioneers. Now that the government has adopted a Land Resettlement policy and decided to help settlers, the graduates of our farm schools, if they decide to discontinue their studies for higher training in agriculture, should consider settling in these farms.

The graduates of technical schools and colleges should ponder on the desirability of continuing the trade of their forefathers instead of venturing into new fields only to become, through lack of adaptation, "square pegs in round holes". Special attention in other countries is given to maintaining an occupation within the family. Skill in any undertaking is developed only over a period of generations. It is for this reason that localities where a certain definite industry has developed and gained momentum through a long series of generations of artisans receive encouragement from the government which sees to it that such industries continue to exist with vigor in that particular region. In advocating the development of the textile industry in the Philippines, we believe that the mechanized textile industry should have as its primary objective the extension of help to the home-weavers in various provinces which have developed the art of weaving by making for them more suitable yarn in a manner that will introduce economy in operation rather than turn out finished products that will eventually kill the home-weaving industry. Excessive mechanization of any industry will tend to throw a large number of workers out of jobs. We could produce one-third of our total imports of textiles through mechanized looms in a central establishment with only 2,000 workers, as against 75,000 home weavers working on home looms with some 400,000 dependents for their life support.

I am in perfect agreement with the recommendations that we do not adopt a policy of self-sufficiency that will call for government subsidy and higher tariff to protect local products, as such a policy will be inimical to the standard of living of most of the people. But I maintain that we have industries that can be developed to supply prime necessities, which, after the initial stages, can readily be produced at lower cost than imported products.

In the development of industries, oftener than not, the profit motive is antagonistic to the interest of the workers. We should change the purely capitalistic philosophy to one of service combined with sound business practice, wherein the profit is reduced to the minimum that labor may adequately be compensated. A realistic re-examination of present day industrial philosophy needs to be made in order that we may adopt that principle best suited to our local conditions. There must be a happy medium between strict capitalism and communism—both rank failures in their extreme forms—which we can adopt—a form of President Quezon's 'Distributive State' that will bring prosperity and happiness to the largest number possible.

Even in such a prosperous country as the great United States of America, the present form of capitalism has done nothing but accumulate the wealth in the hands of a few, and accentuate the exploitation of productive labor. The richest one per cent of the population owns at least fifty-nine per cent of the wealth; the petty capitalists, who constitute twelve per cent of the population, own about thirty-three per cent of the wealth; and the great mass of industrial workers, small farmers, and self employing shopkeepers, who constitute eighty-seven per cent of the population, own but eight per cent of the wealth. (Report on National Wealth and Income, 1926, Federal Trade Commission).

And it is no longer true, as often asserted, that large wealth is dissipated in three generations. Most of the large estates as at present managed not only perpetuate themselves but become larger as they pass from generation to generation.

Under the prevailing distribution of income, even in the most prosperous times, a large proportion of the population lives at or even below the level recognized by Congress as necessary for adequate subsistence.

In a period of depression this same proportion of the population is pressed farther down the scale of living, while those in higher income groups, even though they suffer some reduction of income are in a position to use their vast resources to maintain their accustomed high standard of living. We have a common saying here that the rich always become richer and the poor, poorer. Shall we not try and make this country a better place for the largest number possible?

MULTIPLE BIRTHS IN GOATS AND SHEEP[1]

VALENTE VILLEGAS
Of the Department of Animal Husbandry

The objects of the study reported in this paper were to determine (*a*) the percentage of multiple births in goats and sheep, (*b*) the percentage of multiple births at first parturition, (*c*) the birth weight of the young, (*d*) the sex-ratio, and (*e*) the relation of the birth weight to the weight of the dam.

Heape (1899) presents data on twins in flocks of various breeds of sheep. Suffolk gave the highest, 85.58 per cent, and Lincoln the lowest, 4.16 per cent.

Marshall (1908) reports that flushing almost always resulted in raising the proportion of twins and triplets among Scottish sheep.

In a study conducted by Ainsworth-Davis (1910) with Oxford Down sheep, the results showed that twinning occurred in ewes from ram twins, that ewes from mixed twins gave twice as many female as male offspring, and that ewe twins nearly always delivered male lambs.

Williams and Cunningham (1916) found in their study that single ewes gave 58.65 per cent single lambs, and twin ewes, 55.55 per cent.

Wentworth (1916-1917) concludes that to produce triplets in sheep a different hereditary composition of the dam from that which gives singles or twins is necessary.

Wentworth and Sweet (1917) state that multiple births vary in different breeds of sheep, and that such factors as feeding, vigor of the ewe, season, and region may influence heredity to a marked degree.

From a statistical study of 523 cases of twins in sheep, Clark (1932) is inclined to believe that "twins of dizygotic origin represent the modal class of twin production" in this class of animal.

According to Chapman and Lush (1932), the sex-ratio in sheep is approximately 49 males to 51 females, and that identical twins, if present, are rare. They state that "the genetic portion of the variance in birth weight in the Iowa Agricultural Experiment Station flock of high grade Hampshires can hardly exceed 25 to 30 per cent. The portion of the variance arising from differences in tangible environment is at least 30 to 35 per cent while 40 to 45 per cent or more arises from intangible environment or accidents of development".

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[1] Experiment Station contribution No. 1295. Read before the Fifth Philippine Science Convention on Feb. 22, 1939. Received for publication on March 7, 1939.

This investigation was conducted in the Department of Animal Husbandry from January 9, 1923, to December 9, 1937, covering a period of approximately fifteen years.

Animals

In this study, 461 kids and 112 lambs and their dams were used. The goats were of the stock from which a milch breed of goats for the Philippines was developed. The foundation breeds were native, Indian, and Anglo-Nubian. As the work progressed, the average blood composition of the animals became approximately ¼ native, ¼ Indian, and ½ Anglo-Nubian. Selection for later matings was based principally on the ability of the animals to survive under ordinary conditions, on milk producing ability, and size.

The sheep were grade Indians.

Management

The goats and sheep were herded together to simplify management. In the morning, they were allowed to pasture from 7:00 to 10:00 a. m. and in the afternoon, from 1:00 to 4:00 p. m. At noon and during the night, they were kept in the barn. At all times when the weather was damp and rainy, forages and concentrates were supplied to them in the barn. Corn forage, napier grass, guinea grass, and sometimes butterfly pea (*Centrosema plumieri*), or tapilan hay (*Phaseolus calcaratus*) were given to the animals whenever available. The standard concentrate mixture used consisted of five parts by weight of corn, three parts copra meal, and two parts rice bran. As much of this mixture as would readily be consumed by the animals was placed in the feed-box.

The milking does were managed differently. In the day time they were pastured with the herd, but at night they were placed in a separate pen by themselves where they received soilage and concentrates. The kids were removed from them either in the morning or in the evening and kept in a pen set aside for young animals. In this pen, roughage and concentrates were given to them. The kids were not returned to their mothers until after the latter had been milked. Does that were kidding for the first time were not milked but were allowed to go with the main herd at all times as soon as the kids were big enough to follow their dams in the pasture.

The number of males in the herd was maintained at a ratio of one to about twenty-five females to insure the breeding of all does which came in heat.

Multiple births

From a comparison of multiple births with single births in goats, 121 cases, or 38.3 per cent, were twin births; 18 cases, or 5.7 per cent, triple births; and only 2 cases, or 0.6 per cent, quadruple births. The remaining 175 cases, or 55.4 per cent, were single births.

In sheep, only three cases, or 2.8 per cent, were twin births; and 106 cases, or 97.2 per cent, single births.

With the offspring considered as individual units, 242 kids, or 52.5 per cent, were twins; 36, or 7.8 per cent, triplets; 8, or 1.7 per cent, quadruplets; and the remaining 175, or 38.0 per cent, singles.

In sheep only 6 lambs, or 5.4 per cent, were twins; the remaining 106, or 94.6 per cent, were singles.

Births at first parturition

Out of 60 kids born at first parturition, 52, or 86.7 per cent, were singles; and only 8, or 13.3 per cent, were twins. In sheep there were 15 births at first parturition; all of them were singles.

Birth weight

Single births. It will be seen in table 1 that the males of single birth in goats ranged in weight from 1.2 to 4 kilograms, the mean birth weight being 2.32 ± 0.04 kilograms. The females varied in weight from 1.2 to 4.3 kilograms, the mean being 2.50 ± 0.05 kilograms.

In sheep the mean birth weight of male lambs of single birth was 2.72 ± 0.06 kilograms; the range was from 1.1 to 4 kilograms. Among the females, the mean was 2.46 ± 0.05 kilograms, the variation being from 1.2 to 3.4 kilograms.

Twin births. The males of twin births in goats had a mean weight of 2.13 ± 0.04 kilograms, the range being from 1 to 3.6 kilograms. The females had a mean birth weight of 2.03 ± 0.04 kilograms, the variation being from 0.5 to 3.6 kilograms.

In sheep the mean birth weight of the males was 1.70 ± 0.34 kilograms, and of the females, 2.13 ± 0.20 kilograms. The range in the birth weight of the males was from 1.2 to 2.2 kilograms, and of the females, from 1.3 to 2.7 kilograms.

Triple births. The birth weight of males among the triplets varied from 1.0 to 2.4 kilograms, the mean being 1.73 ± 0.06 kilograms. In the females the minimum weight was 0.8 kilograms, and the maximum, 2.2 kilograms, the mean being 1.67 ± 0.06 kilograms.

Quadruple births. The mean birth weight of the males among the quadruplets was 1.45 ± 0.04 kilograms, the lowest weight being 0.8 kilogram and the highest, 1.8 kilograms. The range in the birth weight of the females was the same as that of the males, but the mean was 1.40 ±0.04 kilograms.

From the foregoing data, it may be seen that the heaviest birth weight was found among single births, the weight of each kid or lamb decreasing as the number of young at birth increased. It was also observed that the difference between the mean weights of male and female kids or lambs in multiple births was not significant.

From a comparison of the weights of litters with the weights of the young in single births, as shown in table 2, the results were as follows:

Twins. The litter weight of twins in goats had a mean value of 3.91 ± 0.06 kilograms as compared with the mean birth weight for singles of both sexes which was 2.42 ± 0.03 kilograms. The range in twins was from 1.9 to 7.9 kilograms, while in singles it was from 1.2 to 4.3 kilograms.

In sheep, the mean litter weight of twins was 3.97 ± 0.49 kilograms, as compared with the mean birth weight of singles of both sexes of 2.60 ± 0.04 kilograms. The range in weight of twins was from 2.5 to 5.0 kilograms, while in singles it was from 1.1 to 4.0 kilograms.

Triplets. In triplets, the mean litter weight in goats was 5.05 ± 0.21 kilograms, the range being from 4.2 to 7.0 kilograms.

Quadruplets. The mean litter weight of quadruplets was 5.7 ± 1.02 kilograms, and the range was from 2.4 to 7.2 kilograms.

It is apparent that as the number of young increased in multiple births in goats and sheep, the litter weight rose considerably.

Sex-ratio

Of the total number of kids produced, 246 were males and 215 were females. In single births, there were 104 males and 71 females; in twins, 120 males and 122 females; in triplets, 18 males and 18 females; and in quadruplets, 4 males and 4 females.

There were 58 male lambs and 54 female. In single births, 56 were males and 50 females; and of the twins, 2 were males and 4 females.

It is evident that in both goats and sheep the relative proportion of males and females in the offspring was about the same. No explanation can be offered for the disproportionately large number of males among single births.

Relation of birth weight to the weight of dam

Single. As may be seen in table 1, the birth weight of male kids in proportion to the weight of their dams in single births was 9.10 ± 0.02 per cent. The range was from 4.13 to 13.63 per cent. In female kids, the range was from 4.7 to 14.36 per cent, and the mean value was 8.96 ± 0.02 per cent. There is then no evident difference.

Referring to the weight of the kids of both sexes in relation to the weight of their dams, as will be seen in table 2, the proportion varied from 4.13 to 14.36 per cent, the mean value being 9.04 ± 0.11 per cent.

In sheep the range in males was from 4.89 to 15.34 per cent, the mean being 9.25 ± 0.22 per cent. In the females, the fluctuation was from 4.47 to 12.16 per cent, and the mean was 8.66 ± 0.20 per cent.

In regard to the relationship of the weight of lambs of both sexes with the weight of their dams, the mean percentage was found to be 8.97 ± 0.15, the range being from 4.47 to 15.34 per cent.

Twins. The range in the percentage weight of the males among twins in goats was from 2.27 to 11.39 per cent and the mean was 7.17 ± 0.12 per cent. With female kids, the mean weight was 6.77 ± 0.09 per cent and the range was from 2.27 to 11.90 per cent.

In the litter weight, the range was from 5.36 to 20 per cent, and the mean was 13.72 ± 0.12 per cent.

In sheep the weight ratio of the male lambs to their mothers ranged from 3.07 to 5.94 per cent with a mean of 4.51 ± 0.97 per cent. In the females, the value varied from 3.33 to 6.01 per cent and the mean was 4.85 ± 0.38 per cent. With both sexes the range was from 6.41 to 11.13 per cent, and the mean was 9.14 ± 0.95 per cent.

Triplets. The fluctuation among individual male kids in triplets was from 2.80 to 7.79 per cent, the mean value being 5.80 ± 0.22 per cent. In the case of female kids, the range was from 3.14 to 8.33 per cent, and the mean percentage was 6.05 ± 0.25.

When the litter weight was taken into account, the range was from 11.23 to 23.37 per cent and the mean was 17.15 ± 0.70 per cent.

Quadruplets. Among the male kids in quadruplets, the variation was from 3.30 to 5.78 per cent, and the mean was 5.10 ± 0.40 per cent. In the females the range was from 3.30 to 5.66 per cent, the mean being 4.89 ± 0.38 per cent.

In litter weight there was a variation of from 10.28 to 17.36 per cent, the mean being 13.82 ± 0.24 per cent.

In all cases, the difference between the means of the relation of birth weight to the weight of dam of males and females in both sheep and goats was not significant.

It was observed in goats and sheep that as the number of young to a litter in multiple births increased, the ratio of the birth weight of the individual young to that of the dam decreased. On the other hand, the ratio of the litter weight to the weight of dam rose as the number of young increased, except in the case of quadruplets in goats, in which the ratio of litter weight to the weight of the dam was about equal to that in twins.

SUMMARY AND CONCLUSIONS

1. In this study, 461 kids and 112 lambs were used. The original stock of goats was of the Native, Indian, and Anglo-Nubian breeds. As the work progressed, the proportion of the different breeds in individual offspring became variable.

2. Of the goats, 55.4 per cent were single births; 38.3 per cent, twin births; 5.7 per cent, triple births; and only 0.6 per cent, quadruple births. In sheep 97.2 per cent were single births, and 2.8 per cent were twins.

3. With the offspring taken individually as units, 38.0 per cent of the kids were single births; 52.5 per cent, twins; 7.8 per cent,

triplets; and 1.7 per cent, quadruplets. In sheep 94.6 per cent were singles, and only 5.4 per cent, twins.

4. Of kids born at first parturition 86.7 per cent were singles and only 13.3 per cent, twins. In sheep, all births at first parturition were singles.

5. The mean birth weights of young goats in single and multiple births of either sex follow:

	MALE *kgm.*	FEMALE *kgm.*
Singles	2.32 ± 0.04	2.50 ± 0.05
Twins	2.13 ± 0.04	2.03 ± 0.04
Triplets	1.73 ± 0.06	1.67 ± 0.06
Quadruplets	1.45 ± 0.04	1.40 ± 0.04

In sheep the mean birth weights of single and twin lambs of either sex were:

	MALE *kgm.*	FEMALE *kgm.*
Singles	2.72 ± 0.06	2.46 ± 0.05
Twins	1.70 ± 0.34	2.13 ± 0.20

The difference in the mean weight at birth of male and female sheep and goats was not significant.

6. The means of litter weights of goats and sheep were as follows:

	GOATS *kgm.*	SHEEP *kgm.*
Singles	2.42 ± 0.03	2.60 ± 0.04
Twins	3.91 ± 0.06	3.97 ± 0.49
Triplets	5.05 ± 0.21	
Quadruplets	5.70 ± 1.02	

7. There were 246 males and 215 female kids included in this study. Of these 104 males and 71 females were born single; 120 males and 122 females, twins; 18 males and 18 females, triplets; and 4 males and 4 females, quadruplets.

In the sheep, 58 were males and 54 females. Of these, 56 males and 50 females were born single; and 2 males and 4 females, twins.

8. The mean ratio of birth weight of young to weight of dam in single and multiple births of either sex in goats follows:

	MALE *per cent*	FEMALE *per cent*
Singles	9.10 ± 0.02	8.96 ± 0.02
Twins	7.17 ± 0.12	6.77 ± 0.09
Triplets	5.80 ± 0.22	6.05 ± 0.25
Quadruplets	5.10 ± 0.40	4.89 ± 0.38

In sheep, the mean ratio of birth weight of lambs to the weight of dams of either sex was as follows:

	MALE *per cent*	FEMALE *per cent*
Singles	9.25 ± 0.22	8.66 ± 0.20
Twins	4.51 ± 0.97	4.85 ± 0.38

The difference between the ratio of birth weight of young to the weight of dam of male and female goats and sheep is insignificant.

9. When the litter weight is considered, the mean ratio of birth weight of young to weight of dam in sheep and goats follows:

	GOATS *per cent*	SHEEP *per cent*
Singles	9.04 ± 0.11	8.97 ± 0.15
Twins	13.72 ± 0.12	9.14 ± 0.95
Triplets	17.15 ± 0.70	
Quadruplets	13.82 ± 0.24	

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TABLE 1

Birth weight of young in single and multiple births in goats and sheep

NATURE OF BIRTH	BIRTH WEIGHT OF MALES		BIRTH WEIGHT OF FEMALES		RELATION OF BIRTH WEIGHT TO WEIGHT OF DAM IN MALES		RELATION OF BIRTH WEIGHT TO WEIGHT OF DAM IN FEMALES	
	Range	Mean	Range	Mean	Range	Mean	Range	Mean
	kgm.	*kgm.*	*kgm.*	*kgm.*	*per cent*	*per cent*	*per cent*	*per cent*
Goat:								
Single-birth	1.2—4.0	2.32±0.04	1.2—4.3	2.50±0.05	4.13—13.63	9.10±0.02	4.70—14.36	8.96±0.02
Twin-birth	1.0—3.6	2.13±0.04	0.5—3.6	2.03±0.04	2.27—11.39	7.17±0.12	2.27—11.90	6.77±0.09
Triple-birth	1.0—2.4	1.73±0.06	0.8—2.2	1.67±0.06	2.80— 7.79	5.80±0.22	3.14— 8.33	6.05±0.25
Quadruple-birth .	0.8—1.8	1.45±0.04	0.8—1.8	1.40±0.04	3.30— 5.78	5.10±0.40	3.30— 5.66	4.89±0.38
Sheep:								
Single-birth	1.1—4.0	2.72±0.06	1.2—3.4	2.46±0.05	4.89—15.34	9.25±0.22	4.47—12.16	8.66±0.20
Twin-birth	1.2—2.2	1.70±0.34	1.3—2.7	2.13±0.20	3.07— 5.94	4.51±0.97	3.33— 6.01	4.85±0.38

TABLE 2

Litter weight at birth in multiple births in goats and sheep

NATURE OF BIRTH	LITTER WEIGHT		RELATION OF LITTER WEIGHT TO WEIGHT OF DAM	
	Range	Mean	Range	Mean
	kgm.	*kgm.*	*per cent*	*per cent*
Goat:				
Single-birth ...	1.2 – 4.3	2.42 ± 0.03	4.13 – 14.36	9.04 ± 0.11
Twin-birth	1.9 – 7.9	3.91 ± 0.06	5.36 – 20.00	13.72 ± 0.12
Triple-birth ...	3.6 – 7.0	5.05 ± 0.21	11.23 – 23.37	17.15 ± 0.70
Quadruple-birth	4.2 – 7.2	5.70 ± 1.02	10.28 – 17.35	13.82 ± 0.24
Sheep:				
Single-birth ...	1.1 – 4.0	2.60 ± 0.04	4.47 – 15.34	8.97 ± 0.15
Twin-birth	2.5 – 5.0	3.97 ± 0.49	6.41 – 11.13	9.14 ± 0.95

STUDIES ON THE FOOD OF LABORERS' FAMILIES IN MACROHON, LEYTE [1]

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Macrohon is a town with a population of about 14,000 situated on the tip of the western prong of southern Leyte. It is bounded on the north by the municipality of Maasin; on the south, by the municipality of Malitbog; on the east by the Sagpoñgon Mountains and on the west, by the Mindanao Sea. The chief occupations of the inhabitants are farming and fishing. The principal products are coconut, hemp, rice, corn, and sweet potato.

In the study of the food of the laborers of Macrohon the method employed, the apparatus used in the collection of data, and the standard used in the calculation of the number of man units were the same as those used by Santos (1938) in his studies on the plane of nutrition of laborers' families in Calabanga, Camarines Sur. The proximate analyses of the food materials were also taken from the same sources. The actual collection of data was made by the junior author from April 17 to May 24, 1937.

Data on food consumed at meal time in one day and the kind of food matarials with their corresponding amounts and costs were taken. Left-overs were also recorded; but in practically all cases, these were eaten by the children between meals or else eaten by the whole family in the next meal. The number of individuals who ate at each meal and their respective ages and weights in ordinary clothing were recorded. A total of 106 families were surveyed and from two to four families were studied each day.

OBSERVATIONS

Food habits. Ordinarily meals were eaten three times a day—in the morning, at noon, and in the evening. Most field workers breakfasted between seven and eight o'clock, or later, after several hours of early morning work. If the work was situated at some distance from the homes, the laborers carried along their breakfast and lunch, or had these delivered to them by members of their fami-

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lies, usually by the children. Newly married men had their meals delivered by the wives.

The noon meal was generally the heaviest. Many ate only rice and "guinamos" (small salted fish) for breakfast and supper; but usually an additional viand was prepared for lunch. In some families the source of carbohydrate for breakfast and supper was only either sweet potato or cooked unripe Saba banana, or a combination of both, most of the time.

Feasts were common, and on these occasions the people could have good and abundant food, especially meat. Feasts were rather numerous during the time of the year when these studies were conducted.

As in other places, children ate in-between meals, irrespective of the time, and as often as they could get something. The food thus eaten consisted usually of fruits, such as guava, oranges, makopa (*Eugenia javanica* L.), and others that were in season and on which they could lay hands. They sometimes chewed sugar cane in nearby fields or bought bread and cookies sold in stores.

Very little milk and other dairy products were used.

"Tuba", fermented liquor from coco toddy, was popular and was drunk whenever available. Sometimes pickled fish (raw fish cut to pieces, mixed with sliced onion and tomato, and steeped in vinegar), was eaten with the tuba. During feasts, especially, many persons got themselves drunk with this beverage.

Source of food materials. Most of the rice consumed was raised either locally or in neighboring towns. Comparatively only a small portion was imported. Fish was caught in the adjoining sea. All other articles of food except canned goods were raised locally.

Water. The drinking water of the region studied came from a spring. The water was fetched in long, bamboo tubes locally called "sag-ub". This work was usually undertaken by the younger members of the family, especially by the girls. Some families which could afford to have roofs made of galvanized iron used rain water for drinking. Water for washing purposes was taken from open wells, of which there was at least one in each barrio. The water from these wells was rather turbid and too saline for drinking purposes.

RESULTS

Some of the results are given in tables 1 to 6.

Of 172 men and 198 women above 14 years, there were 17 men and 12 women over sixty years old. The oldest man was 90; and the oldest woman, 88 years old. The heaviest man weighed 83; and the heaviest woman, 64 kilograms. The average weight of men above 14 years old was 52 kilograms. The average number of persons in a family was 5.69. The biggest family had 17 members.

The daily food per man unit cost from 2 to 23 centavos, with an average of 10 centavos. Similar items for other towns were as follows:

	Range centavos	*Average centavos*
Sta. Catalina	4–25	11
Paoay	7–38	18
Calabanga (Santos, 1938)	6–22	12

Corn and rice were used in practically the same extent, depending on their availability and on the financial ability of the family. Rice is more expensive than corn. In most cases sliced sweet potato was mixed with the rice or corn. Sometimes rice, corn, and sliced sweet potato were mixed and cooked together. The most common food materials used for viand were, in the order of their popularity, "guinamos",[2] "solid-solid" (*Caesio caerulaureus* Lacépède), sugar, mangko (tuliñgan or tunas), onions, fresh or dried "bolinao" (*Stolephorus* spp.), and tomatoes.

It has been estimated by Santos and Adriano (1928) that an average adult Filipino should have the following daily intake: proteins, 80 grams; fats, 40 grams; carbohydrates, 450 grams; and calories, 2,500. Table 1 shows that of 106 families, 52 or 49 per cent had a daily man unit protein intake of 70 grams or above; only 19 families, or 18 per cent, had a fat intake of 30 grams or above; 38 families, or 35 per cent, had a carbohydrate intake of less than 350 grams; and 45 families, or 42 per cent, had an energy intake of less than 2,000 calories.

The average daily intake per man unit (table 2) was: proteins, 76 ± 1.94 grams; fats, 21 ± 1.02 grams; carbohydrates, 420 ± 8.33 grams; minerals, 23 ± 0.79 grams; and a fuel value of 2223 ± 44.38 calories. Compared with corresponding data in other towns studied earlier by Santos, Villanueva, and Silva (1936) and by Santos, (1938), the protein intake in Macrohon was greater than in Sta. Catalina and Pototan, but was about the same as in Paoay and Calabanga. The fat intake was greater than in Sta. Catalina and Pototan, was less than in Calabanga, and about the same as in Paoay. The carbohydrate intake was less than in Calabanga, but higher than in Pototan. Those in Sta. Catalina and Paoay were slightly greater, but the differences were not statistically significant. The mineral intake was less than in Paoay, greater than in Pototan and Calabanga, and about the same as in Sta. Catalina. In energy value, that in Macrohon was greater than in Pototan, but less than in Calabanga. It was slightly higher than in Sta. Catalina and slightly lower than in Paoay, but the differences with these two towns were not statistically significant.

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[2] The popularity of "guinamos" is due to the fact that it is very cheap and is available throughout the year. It is locally descriptive of the financial standing of a family. Thus the expression "sweet potato and guinamos" to describe the daily meals is made to denote almost extreme poverty.

The average daily energy intake (table 3) was 43 calories per kilo body weight, as against 46, 48, 37, and 56 for Sta. Catalina, Paoay, Pototan, and Calabanga, respectively. The corresponding intake for Americans was 49 calories and for Japanese, 53 calories. Fourteen per cent of the calories came from proteins as against only 11.2 per cent, 12.0 per cent, 12.0 per cent, and 9.9 per cent in Sta. Catalina, Paoay, Pototan, and Calabanga, respectively; and 15 per cent for Americans and 13.2 per cent for Japanese.

The protein intake per kilogram body weight was 1.47 grams, as against 1.25 grams, 1.40 grams, 1.08 grams and 1.35 grams for Sta. Catalina, Paoay, Pototan, and Calabanga, respectively. These are all lower than the corresponding intake for Americans (1.79 grams) and for Japanese (1.78 grams).

Of the protein intake (table 4) 63.1 per cent were of plant, and only 36.9 per cent were of animal origin. In the American diet, 60.9 per cent of the proteins were from animal sources. However, the percentage of animal protein in the diet in Macrohon was higher than in the other four towns already mentioned.

Of the total energy intake (table 5), 79.95 per cent was supplied by cereal grains, 10.32 per cent by fruits and vegetables, 6.70 per cent by meat, fish, and eggs, 2.95 per cent by sweet and fatty foods, etc., and an insignificant 0.08 per cent by milk and dairy products. With a few exceptions the same order of magnitude of percentage distribution of calories held true among the other Philippine towns similarly studied. There also exists a striking similarity in this respect with the percentage calorie distribution among the Japanese and North Chinese. That for Americans, however, markedly differs. The calories supplied by cereal grains and sweet and fatty foods, etc., are about the same and together constitute only 57 per cent of the total. The remainder are more or less evenly distributed among the three other sources.

In mineral intake (table 6) the calcium in Macrohon was much lower than the American standard (Rose, 1930) and also lower than the calcium intake of Constabulary soldiers (Concepcion, 1937). The intake of phosphorus and of iron compared favorably with the American standard and with the intake of Constabulary soldiers.

SUMMARY

1. The food of 106 families of laborers in Macrohon, Leyte, was studied by the use of the inventory method.

2. The average weight of the men above 14 years old was 52 kilograms.

3. The daily food per man unit cost 10 centavos, on the average.

4. Rice, corn, and sweet potato were the principal sources of carbohydrates.

5. The most common food materials for viand were "guinamos", "solid-solid", sugar, "mangko", onions, fresh or dried "bolinao", and tomatoes, in the order of their popularity.

6. The average daily intake per man unit of proteins was 76 ± 1.94 grams; of fats, 21 ± 1.02 grams; of carbohydrates, 420 ± 8.33 grams; of minerals 23 ± 0.79 grams; with a total fuel value of 2223 ± 44.38 calories. The fuel value was less than 2500 calories, the tentative standard for Filipinos, but compared well with those in the other towns similarly studied, with the exception of Calabanga. Of the total calories 14 per cent were supplied by proteins and 79.95 per cent by cereal grains. In general, the order of magnitude of percentage calorie distribution among the different food sources was closely similar to those in the other towns previously studied. With respect to minerals, the diet in Macrohon was comparatively low in calcium, but satisfactory in phosphorus and iron.

7. Out of 106 families, 52, or 49 per cent, had a daily man unit protein intake of 70 grams or above; only 19 families, or 18 per cent, had a fat intake of 30 grams or above; 38 families, or 35 per cent, had a carbohydrate intake of less than 350 grams; and 45 families, or 42 per cent, had an energy intake of less than 2000 calories.

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TABLE 1

Food intake and distributions of families

Intake	Number of families	Per cent
PROTEINS		
grams		
Below 50	14	13
50 - 59	19	18
60 - 69	21	20
70 - 79	16	15
80 - 89	13	12
90 or above	23	22
FATS		
grams		
Below 10	16	15
10 - 19	57	54
20 - 29	14	13
30 - 39	5	5
40 - 49	6	6
50 or above	8	7
CARBOHYDRATES		
grams		
Below 350	38	35
350 - 449	26	25
450 - 549	26	25
550 - 649	10	9
650 - 749	5	5
750 or above	1	1
CALORIES		
grams		
Below 2000	45	42
2000 - 2499	24	23
2500 - 2999	23	22
3000 - 3499	11	10
3500 - 3999	1	1
4000 or above	2	2

TABLE 2

Average intake per man unit per day

FAMILIES	PROTEINS	FATS	CARBOHYDRATES	MINERALS	FUEL VALUE
	grams	*grams*	*grams*	*grams*	*calories*
Sta. Catalina, I. S. (Santos, et al, 1936)	60±1.69	15±0.92	456±11.54	24±0.92	2193±51.34
Paoay, I. N. (Santos, et al, 1936)	70±1.56	25±1.28	443±10.38	29±1.47	2387±49.71
Pototan, Iloilo (Santos, et al, 1936)	54±0.37	13±0.20	370± 2.94	8±0.14	1831±11.95
Calabanga, C. S. (Santos, 1938)	70±1.01	33±1.11	564± 6.78	16±0.31	2895±33.54
Macrohon, Leyte	76±1.94	21±1.02	420± 8.33	23±0.79	2223±44.38
DIFFERENCES					
Macrohon—Sta. Catalina	16±2.57	6±1.37	(–) 36±14.23	(–) 1±1.21	30±67.86
Macrohon—Paoay	6±2.49	(–) 4±1.64	(–) 23±13.31	(–) 6±1.67	(–)164±66.64
Macrohon—Pototan	22±1.97	8±1.04	50± 8.83	15±0.80	392±45.96
Macrohon—Calabanga	6±2.19	(–)12±1.51	(–)144±10.70	7±0.85	(–)672±56.86

TABLE 3

Comparative food intake per kilo body weight and calories from proteins

	PC/TC	P/KBW	C/KBW
	per cent	*grams*	*calories*
Sta. Catalina, Ilocos Sur	11.2	1.25	46
Paoay, Ilocos Norte	12.0	1.40	48
Pototan, Iloilo	12.0	1.08	37
Calabanga, Camarines Sur	9.9	1.35	56
Macrohon, Leyte	14.0	1.47	43
American—Medium work (Atwater, *cited* by Lusk, 1928)	15.0	1.79	49
Japanese (Grey, 1928)	13.2	1.78	53

TABLE 4

Distribution of proteins

	ANIMAL	PLANT	CEREALS
	per cent	*per cent*	*per cent*
Sta. Catalina, Ilocos Sur	30.4	69.6	58.1
Paoay, Ilocos Norte	33.4	66.6	46.7
Pototan, Iloilo	34.9	65.1	59.1
Calabanga, Camarines Sur	30.0	70.0	63.0
Macrohon, Leyte	36.9	63.1	55.3
American (Rose, 1930)	60.9	39.1	29.0

TABLE 5

Percentage distribution of calories

	CEREAL GRAINS	MEAT, FISH, EGGS	MILK AND DAIRY PRODUCTS	FRUITS AND VEGETABLES	SWEET AND FATTY FOODS, ETC.
	per cent	*per cent*	*per cent*	*per cent*	*per cent*
Sta. Catalina, Ilocos Sur	89.25	5.31	—	4.19	1.25
Paoay, Ilocos Norte	78.15	10.90	0.25	8.78	1.92
Pototan, Iloilo	90.41	5.94	—	2.59	1.06
Calabanga, Camarines Sur	79.40	4.33	0.05	13.31	2.91
Macrohon, Leyte	79.95	6.70	0.08	10.32	2.95
American (Rose, 1930)	30	15	13	15	27
Japanese (Grey, 1928)	66	13	—	15	6
North Chinese (Wu, *cited* by Concepcion, 1933)	72	6.8	0.06	8.7	12.6

TABLE 6

Comparative mineral intake

	CALCIUM	PHOSPHORUS	IRON
	grams	*grams*	*grams*
American standard (Rose, 1930)	0.690	1.320	0.015
Constabulary (Concepcion, 1937)	0.347	1.230	0.015
Macrohon, Leyte	0.209	1.423	0.022

COST OF PRODUCING PIGS AT THE COLLEGE OF AGRICULTURE [1]

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Profit or loss in any business enterprise can be determined only when the cost of production and the selling price of the products are known. Profit is realized when the market price is above cost; a loss is incurred when it is below cost.

Philippine hog raisers in general have little or no idea of what it costs to raise their pigs. The prevailing belief is that when little or no cash is involved, there is little or nothing to account for. This lack of knowledge on the cost of production is, in large measure, responsible for the present anomalous condition and situation of the hog market. It has placed the butcher or the dealer in a position to dictate both the price of the hog and the price of pork regardless of the cost of production and of the supply and demand, and has kept many interested people from taking up the business of swine production. Statistical figures [2] for 1922 to 1932 and personal observation and study of prices in and about Manila from 1933 to 1937 show that the prices of hogs have been uniformly low, much lower than they should have been in relation to the prices of pork paid by the consumer and to cost of production even by the best methods known. The market price of 70-kilogram hogs in and about Manila ranges from ₱9.00 to ₱15.00, or at the rate of ₱13.00 to ₱21.00 a hundred kilogram live weight, while pork retails from ₱0.50 to ₱1.00 a kilogram.

These irregularities in the hog market can be improved and will improve if and when the hog producers know what it costs them to produce their hogs.

If the swine enterprise is so organized that it operates on standard materials and on well established methods of feeding and care, it is possible not only to produce standard products but also to establish a typical cost of production. Once known, expressed by a constant term, it will serve as a basis for comparison with the market price of hogs which varies from time to time.

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[1] Experiment Station contribution No. 1297. Read before the Los Baños Biological Club, December 15, 1938.

[2] Statistical Handbook of the Philippine Islands. 1932. Department of Agriculture and Natural Resources.

The lack of data on the subject and the fundamental importance of the matter prompted the undertaking of this study with the hope that the data obtained may serve as a basis of computation for those interested in the swine business with nothing locally to guide them.

Review of literature

Smith (1929) reported that the average cost of producing a 225 pound (102 kgm.) market pig from a mature sow having three litters in two years and weaning seven pigs in a litter is 1:10.92; that is, it takes the equivalent value of 10.92 bushels of corn to produce a 100 pound live weight hog. This is equivalent to 100-kilogram live weight to 627 kilograms corn (feed), or a production ratio of 1:6.3.

Wallace (1920) reported that the ratio method of price determination was first recognized in the United States in 1917 and that it actually expresses cost of production. According to the author, the hog producers of eighty years ago without any statistical study or without keeping detailed account of expenses, came to the conclusion that they could make money any time they sold their hogs for a value per 100 pound (45.36 kgm.) weight of more than 10 bushels (274.9 kgm.) of corn—a production ratio of 1:10. He presented the yearly corn-hog market ratio from 1858 to 1917 which he averaged as follows:

PERIODS	MARKET RATIO *bushels*	MARKET RATIO *kgm.*
1858–1867	1:10.6	1:6.5
1868–1877	1:11.7	1:7.1
1878–1887	1:11.0	1:6.7
1888–1897	1:11.8	1:7.2
1898–1907	1:12.2	1:7.4
1908–1917	1:11.3	1:6.9
Average of 60 years	1:11.4	1:7.0

Object of the study

The object of this study was to determine the cost of producing pigs as follows: (1) 80-kgm. barrow, (2) 80-kgm. gilt, (3) 80-kgm. boar, (4) the first litter weaned, (5) the second litter weaned, and (6) the third litter weaned.

Time and place of the work

The study on the growth and development and feed consumption of the barrows, gilts and boars was started in April of 1936 and terminated in February, 1937. The work on the cost of producing the litters was started in July, 1935, and was completed in June, 1938. The study was conducted in the Department of Animal Husbandry, College of Agriculture.

Plan of the study

An opportunity to carry out this study came when Dr. B. M. Gonzalez, Head of the Department of Animal Husbandry and Dean of the College of Agriculture, proposed to start, in 1936, a periodic one-year inventory of the performance of the Berkjala breed of swine, one such inventory to be taken at the end of every five-year period. Animals placed under observation for the purpose were to be fed and handled by the best method known at the time. They were not to be sold or butchered until they had completed one year of age and not to be placed under any experiment using untried feeds or methods of handling.

Animals used. Fourteen gilts, fourteen barrows, ten boars, and ten sows and their litters were included in this study. Only those sows that produced their third litters were included in the study so the first, second, and third litters produced by the same sows could be compared with one another.

Feeds and rations used. Following are the feeds and feed mixtures used, these being the standard rations of the College:

FEED CONSTITUENTS PARTS BY WEIGHT	FEED MIXTURES				
	No. 1	No. 2	No. 3	No. 4	No. 5
Corn	10	15	20	25	30
Rice bran	60	60	60	60	60
Copra meal	20	18	16	13	9
Fish meal	10	7	4	2	1
Total	100	100	100	100	100

To every 100 kilograms of the above feed mixtures, one kilogram of a mineral mixture consisting of equal parts by weight of common salt and corncob or wood charcoal was added.

Management

During the nursing period, sows with their litters were kept in the hog pens. However, the sows were allowed to go out into a separate yard two or three times a day regularly, while the pigs were allowed to go out at will into the yard adjoining the nursing pens. All nursing sows were given ration mixture No. 1. They were fed all they could consume twice a day. In addition to the concentrate feed, camote soilage at the rate of one kilogram per one hundred kilogram live weight was given. The nursing pigs were taught to eat grains when about three weeks old, receiving ration mixture No. 1 in the form of thick slop.

Weanling pigs, from two to six months of age, were on a grain-pasture system of feeding, receiving a full ration of feed mixture No. 2. Barrows and gilts from six to ten months old were on a grain-soilage system of feeding and on feed mixture No. 4. Then they were fed in the dry lot receiving ration mixture No. 5 until they reached an average weight of 80 kilograms.

The boars from six months of age until they reached a weight of 80 kilograms were on a grain-pasture system of feeding and on ration mixture No. 3.

All animals in gestation were on a grain-pasture system of feeding. As the gestation period advanced, however, the grain ration allowed was varied from limited to full amount with access to pasture. Access to pasture was from full to limited until a few days before farrowing when the sows were taken from the pasture, kept closely confined in pens, and given only grains. Gilts or yearlings in gestation received ration mixture No. 2; two year-old sows, ration mixture No. 3; and mature sows, ration mixture No. 4. The gilts received feed at the rate of about 2 kilograms per 100 kilogram live weight; two-year old sows, 1.5 kilograms; and mature sows, 1 kilogram. More feed was given whenever the pasture was poor and the animals appeared low in condition; less, when the animals were on good pasture and when they showed a tendency to fatten. The final criterion is the response of the animals judged by their appearance and activity.

After weaning, or during the flushing period, the sows were fed mixtures Nos. 2, 3, or 4 and in varying amounts depending on their age and condition. They were bred when in optimum condition, neither thin nor fat. The flushing period averaged about two months.

Bases used in the computation of the various items of cost

The College herd. The herd under average or normal conditions is being maintained at about 200 head; the yearly range is from 150 to 250.

The site. The land exclusively set aside for the piggery is three hectares valued at ₱250 a hectare or a total of ₱750.

Permanent improvement and equipment. The hog house, exclusive of the butcher shop and judging pavilion, but including accessories (wallow, water system, runways, etc.) is worth ₱750.00; fences, ₱402.00; Fairbanks balance, ₱80.00; miscellaneous tools and minor equipment, ₱28.00, all amounting to a total of ₱1250, which is about one half of the original value when newly constructed or purchased. The total present value of the property is about ₱2000.

The caretaker. The caretaker received a daily wage of ₱1.00 or ₱365 a year. He did all the feeding, mixing of feed, cleaning, minor repairs, making of wooden troughs, and helped in butchering. He worked exclusively in the piggery.

The manager or the farmer. For the manager of the whole business of farming, it is assumed that a salary of ₱1,200 a year is reasonable. The swine project is estimated to be one-fifth of the whole farm enterprise he is managing so that he devotes only one-fifth of his time to the project; thus, only one-fifth of his salary is charged against the piggery.

Feed. The actual amount and cost of feed consumed was charged in every case.

Pasture. The cost of planting one hectare of sweet potatoes was ₱32.50.[3] Two hectares or less of camote pasture are planted a year, for the use of the entire herd. When there was little or no camote pasture available, the pigs were turned on grass pasture, or given soilage only.

Items of cost

All items of cost were divided into three principal parts: namely, feed cost, labor cost, and other costs which consist largely of overhead. The method of computation follows:

Feed cost. Under this item were included concentrates, mineral mixture and pasture. The average amount of feed consumed by the barrow, for instance (see table 1), was 284 kilograms the cost of which, at the rate of 4 centavos a kilogram, amounted to ₱11.36; 2.84 kilograms mineral mixture at 4 centavos a kilogram amounted to ₱0.11. The cost of the pasture for the entire herd was ₱65.00. This amounted to ₱0.33 a pig a year or ₱0.26 a pig for 304 days, the length of time it took the barrow to reach 80 kilograms and finish.

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[3] The figures on cost of equipment and preparation of pasture were furnished by Mr. J. P. Esguerra of the Department of Animal Husbandry.

Labor cost. One-fifth of the salary of the manager, amounting to ₱240.00, was charged against the swine project of 200 head, or at the rate of ₱1.20 per head a year. At this rate, the charge per pig was ₱1.00 for 304 days. The caretaker received ₱1.00 a day for taking care of the entire herd. Accordingly, the charge per pig was ₱0.005 a day or ₱1.52 for 304 days.

Other costs. The cost of a weanling pig amounting to ₱3.62 represented the average cost of producing weanling pigs from the first, second, and third litters. Interest at 6 per cent and insurance at 2 per cent were charged on the average value of the pig which was obtained by adding the initial investment of ₱3.62 to the final value or investment on the pig of ₱20.00 (80 kgm. @ 25 centavos). The sum of ₱23.62 divided by 2 gives ₱11.81 as the average investment on the pig for 304 days. The interest and insurance amounted to ₱0.79. The rent on land valued at ₱750 at 6 per cent was ₱45.00. This was charged against the entire herd making the rate a year to be ₱0.23 per head, or ₱0.18 for 304 days. The interest at 6 per cent, depreciation at 10 per cent, and insurance at 2 per cent on ₱1,250 worth of equipment were obtained in like manner. Two thousand pesos was the value of property invested in the swine project on which the tax of seven-eighths of one centavo should be divided by the number of hogs using the property. Miscellaneous cost is made up of expenses for drugs, empty oil cans, etc.

RESULTS

The results are presented in tables 1, 2, and 3.

DISCUSSION OF RESULTS

It may be noted that a barrow costs less to produce than a gilt or a boar. Castrated animals invariably gained in weight more rapidly and required less feed per unit of gain than the uncastrated animals. Castration made them less active, and they grew and fattened more rapidly. The results explain the reason why hog feeders prefer castrated weanlings pigs to female pigs, the selling price of the former being usually 20 to 30 per cent more than the latter, weight for weight.

A gilt costs less to produce than a boar because normally oestrum, which is usually attended with loss or no gain in weight, lasts about 4 days and recurs only every 21 days. The boar, on the other hand, experiences sexual excitement most of the time and every time a sow in the herd comes in heat; consequently its growth is disturbed for a longer period and it loses more weight.

Although the boar is the costliest of the three classes of pigs to produce, its value is not for its meat but for breeding. Properly selected and with ability to transmit the quality desired, its value for reproduction is usually many times more than the pig whose value is for meat only. At this College, and likely elsewhere, selected breeding pigs often command a selling price two times or more than that of market pigs.

It appears that of the total cost of production the feed item of the barrow, gilt, and boar constitutes about 72 per cent; labor, 14 per cent; and overhead, 14 per cent. Smith (1929) reports an average of 72 per cent feed cost and the remaining 28 per cent more or less equally divided between labor and overhead.

The cost of producing the gains in weight of nursing pigs was more than that in the succeeding feeding periods, growing and fattening. The cost per 100 kilogram gain ranged from ₱38.31 in the first litter to ₱44.73 in the third litter. During the growing and fattening period the cost per 100 kilogram gain was ₱23.27 in the barrow, ₱25.20 for the gilt, and ₱28.56 for the boar. The reason it cost more to produce the gain in weight made in the nursing period than that made succeedingly is that it cost more to convert feed of the sow into milk and then the milk of the sow into flesh of the nursing pigs. Furthermore, the sow loses weight almost invariably indicating that part of the sow's flesh is converted into milk before this is converted into the flesh of the nursing pigs. On the other hand, the gain in weight made in the succeeding period is a direct conversion from feed to flesh, with feed being much cheaper than the milk and flesh of the sow as sources for the gain in weight of nursing pigs. This explains why the selling price of weanling pigs weight for weight is usually about twice as high as that of the butcher hog. When butcher hogs sell at ₱25.00 a hundred kilograms, weanling pigs sell at about ₱50.00 a hundred kilograms.

It may be noted that the cost of producing the first litter is lower than that of the succeeding litters. This is expected beacause the yearling sow is still growing and the increase in weight is an increase in its value for pork which when credited after weaning lowers the cost of producing the litter. On the other hand, a mature sow not only does not grow anymore but it may even lose in weight and depreciate in value. This depreciation must be added to the cost of the litter. However, as long as a sow continues to reproduce efficiently, even if the cost of production of the litter increases, it should be allowed to reproduce, because the value of her pigs for breeding purposes increases more than the increase in their cost of production. Breeding pigs are sold at the College at a price usually double that of the price of market pigs. Weanling pigs for breeding are sold at ₱1.00 a kilogram; for growing and fattening, at ₱0.50 a kilogram. In the United States select breeding animals from well known strains are sold at prices varying from hundreds to thousands of dollars per head. Because the cost of production increases with the advance in the age of the sows, no sows that are inefficient in the performance of this function, should be kept in the breeding herd.

As may be noted, the cost of production may be expressed in terms of pesos, percentage, kilogram-feed, or hog-feed ratio. The question is, which of them expresses more truly and accurately the typical cost of production? It cannot be in pesos because its value or purchasing power from time to time is variable. It cannot be in percentage because, although constant, it represents any resulting cost in pesos. What is constant, however, and at the same time fairly represents the true cost is the amount of feed required, the amount of labor hours and the overhead charges. The difficulty lies in that they cannot be added, being of dissimilar quantities or units. Nevertheless, they can be converted into a common term, in kilogram-feed or still better in hog-feed ratio for, as far as hog production is concerned, hog and feed are one and the same in different forms. Furthermore, feed constitutes the biggest item of the total cost, 72 per cent. Thus, the total cost of producing barrows per 100-kilogram live weight is ₱24.89. When the price of the feed averaged 4 centavos a kilogram as was the case at the time this study was made, reduced to the kilogram-feed basis, the equivalent of ₱24.89 is 622 kilograms feed; that is every 100-kilogram live weight produced required, for feed, labor, etc., the expenditure of an amount equal to the value of 622 kilograms feed. The production ratio, therefore, is 1:6.22 which is fairly constant as long as the same materials and system of feeding are employed.

An American hogman when asked what it costs him to produce his pigs will invariably answer in terms of the hog-corn ratio, saying 1:10 or whatever his production ratio may be, meaning that it costs him to produce 100 pounds or a hundred pound live weight hog the value of 10 bushels of corn. As long as he gets a return that will buy 10 bushels of corn, he does not lose when he markets his pigs.

The average production ratio for the barrow at the College of Agriculture is 1:6.22. When hogs sell at ₱25.00 a hundred kilograms and the market price of the feed is ₱3.00 for a hundred kilograms, the market ratio is 1:8.33. When the College sells hogs at this ratio, it will gain because from the ₱25.00 return 833 kilograms feed can be purchased again. The gain is 211 kilograms feed worth ₱6.33. If, on another market day, the market quotation for hogs is ₱30.00 and the feed is ₱6.00, the market ratio is 1:5.0. If the College sells at this time, it will incur a loss of 122 kilograms feed or ₱7.32.

At a glance, it may seem unreasonable to believe that when the cost of production is ₱24.89 and the selling price is ₱30.00, the College would lose in the transaction. However, the fact that the ₱30.00 return could only purchase 500 of the 622 kilograms feed spent in its production shows that the College must certainly lose. It means simply that the purchasing power of the peso is less. One peso now is equal to only 68 per cent (₱0.68) of its value at the time this determination of cost was conducted. One peso then could purchase 25 kilograms feed; now it can only purchase 17 kilograms. Hence, the limitations of figuring the cost of production in terms of pesos, the value of which in terms of feed is subject to fluctuations; hence, the wisdom of expressing it in terms of the hog-feed ratio which is both simple and constant. Any time that the market ratio is wider than the production ratio, marketing is favorable; when narrower, it is unfavorable.

SUMMARY AND CONCLUSION

The probable average or typical cost of producing different classes of pigs, when the Berkjala breed of swine, the same facilities, labor, feeds, and systems of handling are used as are employed in this study, is herewith reported. Based on 100 kilogram live weight produced, the costs of production, in terms of hog-feed ratios are as follows:

1. The cost of producing an 80 kgm. barrow is 1:6.2.
2. The cost of producing an 80 kgm. gilt is 1:6.7.
3. The cost of producing the first litter is 1:9.6.
4. The cost of producing the first litter is 1:9.6.
5. The cost of producing the second litter is 1:10.6.
6. The cost of producing the third litter is 1:11.2.

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TABLE 1

The average cost of producing different classes of pigs

ITEMS	80-KGM. BARROW FEEDING PERIOD, 304 DAYS [a]		80-KGM. GILT FEEDING PERIOD, 315 DAYS [a]		80-KGM. BOAR FEEDING PERIOD, 348 DAYS [a]	
I. Feed cost	284 kgm.—		313 kgm.—		341 kgm.—	
1. Concentrate	₱11.36		₱12.52		₱13.64	
2. Mineral mixture	2.84 kgm.—		3.13 kgm.—		3.41 kgm.—	
	0.11		0.13		0.14	
3. Pasture	0.26	₱11.73	0.28	₱12.93	0.31	₱14.09
II. Labor costs						
1. Manager	1.00		1.04		1.15	
2. Caretaker	1.52	2.52	1.57	2.61	1.74	2.89
III. Other costs						
1. Cost of weanling pig	3.62		3.62		7.24	
2. Interest and insurance on ave. value of pig	0.79		0.81		1.50	
3. Land rent	0.18		0.19		0.21	
4. Int., depr. and ins. on value of equipments	0.94		0.98		1.15	
5. Property tax	0.07		0.07		0.08	
6. Miscellaneous	0.06	5.66	0.06	5.73	0.07	10.25
Total cost		₱19.91		₱21.27		₱27.23
Cost based on 100 kgm. weight		24.89		26.59		34.04
Production ratio		1:6.2		1:6.7		1:8.5

[a] This refers to the feeding of the pigs starting from the time they were weaned to the time they attained the weight of 80 kilograms.

TABLE 2

The average cost of producing litters to weaning age

ITEMS	FIRST LITTERS 479-DAY PERIOD [a]			SECOND LITTERS 712-DAY PERIOD [a]			THIRD LITTERS 955-DAY OR OVER [a]		
I. Feed cost									
1. Weanling to breeding	1st	₱11.83		2nd	₱33.54		3rd	₱52.88	
2. During gestation	"	9.59		"	7.39		"	6.68	
3. During lactation	"	6.84	₱28.26	"	6.79	₱47.72	"	6.15	₱65.71
II. Labor cost									
1. Manager		1.58			2.35			3.15	
2. Caretaker		2.39	3.97		3.56	5.91		4.77	7.92
III. Other costs									
1. Cost of weanling sow pig		5.00			5.00			5.00	
2. Interest and insurance on average value of sow		1.51			2.40			3.90	
3. Land rent		0.29			0.43			0.57	
4. Int., depr., and ins. on value of equipment		1.58			2.35			3.15	
5. Service fee of boar		2.00			4.00			6.00	
6. Property tax		1.11			0.17			0.23	
7. Miscellaneous		0.09	₱10.58		0.14	₱14.49		0.19	₱19.04
Total cost			₱42.81			₱68.12			₱92.67
Cr. cost of previous litter		₱ 0.00			₱19.06			₱42.37	
Cr. value of sow		23.75	₱23.75		25.75	₱44.81		24.80	₱67.17
Cost of producing the litter			₱19.06			₱23,31			₱25.50
The average size of litter weaned	5 pigs			6.5 pigs			7 pigs		
The average cost per pig weaned		₱ 3.81			₱ 3.59			₱ 3.64	
The average weight of litter weaned	49.75 kgm.			54.75 kgm.			57.00 kgm.		
Cost per 100 weight		₱38.31			₱42.57			₱44.73	
Production ratio		1:9.6			1:10.6			1:11.2	

[a] This refers to the feeding period starting from the time the sow pig is weaned to the time she weans her last litter.

TABLE 3

The cost of producing pigs based on 100 kilograms live weight in terms of pesos, percentage, kilogram feed, and production ratio

CLASSES OF PIGS	ITEMS OF COST			TOTAL COST	PRODUCTION RATIO IN KGM. (HOG-FEED RATIO)
	Feed	Labor	Overhead		
Barrows	₱17.92 72% 447 kgm.	₱3.73 15% 93 kgm.	₱3.24 13% 82 kgm.	₱24.89 100% 622 kgm.	1:6.22
Gilts	₱19.41 73% 485 kgm.	₱3.99 15% 100 kgm.	₱3.19 12% 80 kgm.	₱26.59 100% 665 kgm.	1:6.65
Boars	₱24.51 72% 613 kgm.	₱4.42 13% 110 kgm.	₱5.11 15% 128 kgm.	₱34.04 100% 851 kgm.	1:8.51
Weanlings from first litter	₱28.73 75% 719 kgm.	₱5.36 14% 134 kgm.	₱4.22 11% 105 kgm.	₱38.31 100% 958 kgm.	1:9.58
Weanlings from second litter	₱32.63 76% 808 kgm.	₱3.87 9% 96 kgm.	₱6.44 15% 160 kgm.	₱42.57 100% 1,064 kgm.	1:10.64
Weanlings from subsequent litters	₱33.36 75% 838 kgm.	₱4.00 9% 101 kgm.	₱7.12 16% 179 kgm.	₱44.73 100% 1,118 kgm.	1:11.2

RAMIE AND ITS CULTIVATION IN DAVAO[1]

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WITH FOUR TEXT FIGURES AND ONE CHART

Ramie, or China grass, *Boehmeria nivea* (Linn.) Gaudich., is a perennial fiber producing shrub belonging to the Urticaceae, or nettle family. It is grown extensively by two well-organized Japanese companies in Davao. About 300 hectares are planted to it on the Ohta Development Company, Furukawa, and other plantations.

The methods of culture of the crop, and the preparation of ramie fiber, which have been found successful and put into practice by Director Uichi Kojima of the Ohta Development Company are here treated briefly with the hope that they may be of help to planters who are interested in the culture of the plant.

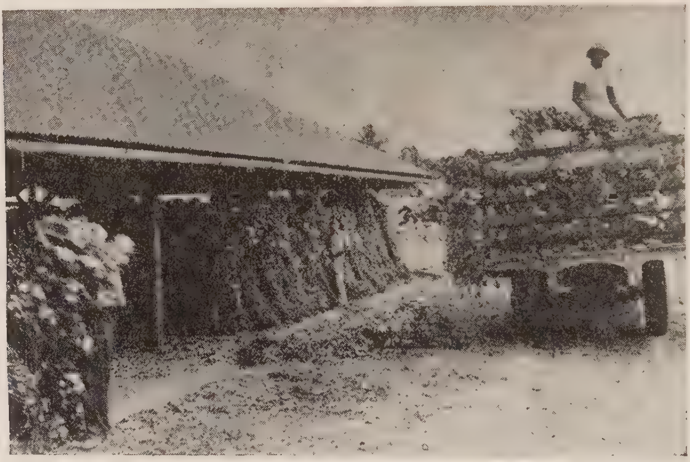

Photo courtesy Ohta Dev. Co.

Fig. 1.—Ramie in bundles brought to the stripping shed.

Variety. The variety in culture was introduced from Japan and is called "*Saikeiseisin.*" In this word, *sai* means fine; *kei,* stem; *sei,* green; and *sin,* pith. It requires much rain and soil with an abundance of compost. This variety bears more or less circular leaves whose lower surface is white, and produces a high percentage of fiber.

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[1] General contribution from the College of Agriculture No. 680. Read before the Los Baños Biological Club on October 27, 1938.

Climatic and soil requirements. Ramie requires a warm moist climate for profitable cultivation. It grows best on fertile sandy-loam, alluvial, and forest, or humus soils with good drainage. It is adversely affected by drought. It will not grow on swampy or stiff clay soils. In Davao, where the soil and climate are especially adapted to abacá, ramie thrives well.

Propagation. Ramie is propagated by suckers which are separated from the mother stalks and planted about 80 centimeters apart in rows distanced 60 centimeters from each other. Ramie can also be propagated by rootstock cut into pieces 20 to 25 centimeters long and planted in a slanting position with about one-third of the length above ground.

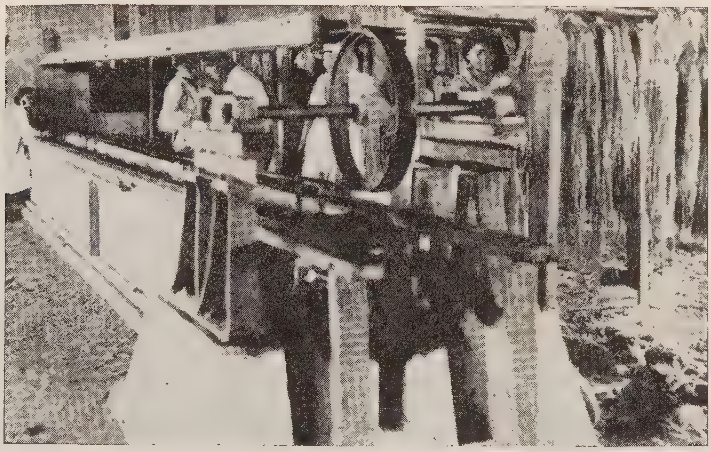

Photo courtesy Ohta Dev. Co.

Fig. 2.—Ramie decorticating machine.

Cultivation. The land between the rows is cultivated during the first year mostly by hand in order to keep down the weeds. Cultivation is done after a crop is harvested; when leaves are cut off the stems in the field, they are spread over the ground. After the fiber has been extracted in the mill, all residue (cut leaves, stems, and pulp) is returned to the field.

Fertilizer. Ramie reacts easily to the fertility of the soil and fertilization. Although this plant is usually grown on rich soil, a certain amount of fertilizer is applied to guard against a decrease in yield. In addition, therefore, to the leaves, stems, and pulp, which are returned to the soil after the fiber has been extracted, sulphate of ammonia is applied at the rate of 200 kilograms per hectare.

Harvesting. The first crop of ramie fiber is usually harvested by hand after six months from planting, or when the plants show brown bark on one-third their lengths. After the first cutting, four or five more crops may be obtained each year, depending on the soil fertility and climatic conditions. Experiments by the Ohta Development Company show that six cuttings a year are possible.

The following information on the age and condition of shoots or sprouts after cutting was obtained from Director Kojima of the Ohta Development Company:

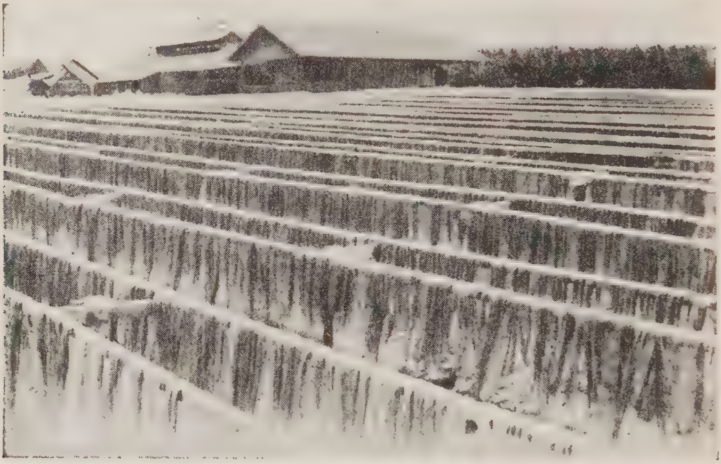

Photo courtesy Ohta Dev. Co.

Fig. 3.—Drying ramie fiber in the sun.

Age of shoots from cutting	*Condition of shoots or sprouts*
10 days after cutting	One foot high.
30–40 " " "	About man's height.
40–50 " " "	Maturing age.
50–60 " " "	Ready for harvesting. (Experiments show that this is the best stage for harvesting).

Preparation of the fiber. The cut stems are brought to the machine shed for decortication (fig. 1). The separation of the fiber from the stem is done by the Ohta Development Company with a ₱20,000 machine, invented by a Japanese. A small machine costing

₱180 is also used with a 2½ h. p. engine exclusively for cleaning ramie fiber. On the Furukawa Plantations, cleaning ramie, abacá, maguey, and sisal fibers is done with a "Corona Machine" costing ₱50,000, and run by a 65 h. p. engine.

The big machine used by the Ohta Development Company has a total output of 30 to 40 piculs of fiber a day. In its operation it requires the services of 30 to 40 Filipino laborers and one Japanese mechanic. For the small machine, three men are needed and the output is about one picul a day. One man is needed for stripping, one for delivering the stems or stalks, and one for combing and drying the fiber.

The different steps in cleaning ramie fiber on the Ohta Development Company Plantation are:

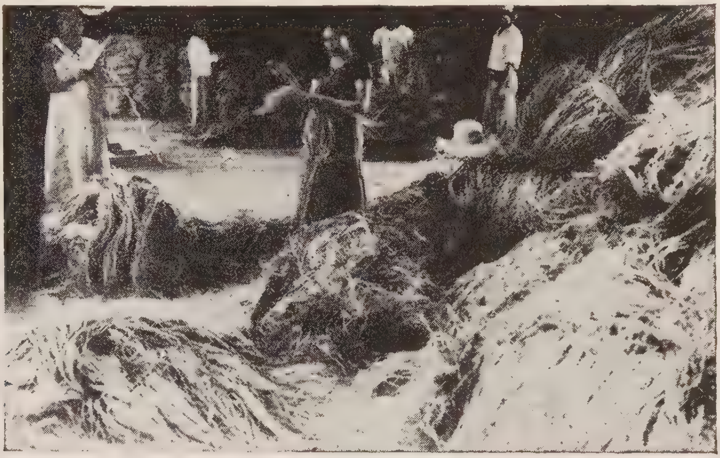

Photo courtesy Ohta Dev. Co.

Fig. 4.—Classifying ramie fiber.

(1) Tying stems into bundles, each containing 20 to 30 stems, in the field and transporting them to the stripping shed (fig. 1).

(2) Depulping with machine (fig. 2).

(3) Bleaching the fiber with SO_2 vapor to prevent molds and to produce soft white fiber.

(4) Drying the fiber in the sun (fig. 3).

(5) Brushing the fiber with a machine.

(6) Grading according to length and color (fig. 4).

(7) Baling.

Cost of production. According to Director Kojima, in the first year, the cost of producing one picul of ramie fiber including operation from cutting to cleaning is about ₱13.00 or ₱0.205 per kilogram. To this must be added the expenses for land preparation and planting. After the first crop, the cost of production is only for weeding, fertilizing, and preparing the fiber for market.

Yield. Under Davao conditions, the highest average yield per hectare each harvest is 15 piculs of dry fiber; the lowest, 5 piculs. On the Ohta Development Company plantation, the yield per hectare from first to third cuttings are:

Cutting	*Piculs dry fiber per hectare*
First	3
Second	5–6
Third	6–10

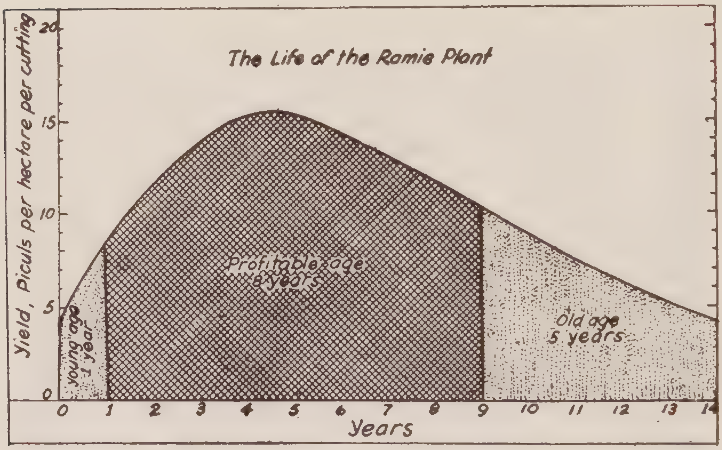

Chart 1.—Yield curve in relation to the age of ramie.

In the second year, the average yield per hectare is 40 to 45 piculs of dry fiber. The yield decreases as the plants become older. The yield curve in relation to age of ramie as shown in chart 1 was given to the writer by Director Kojima of the Ohta Development Company.

Pests. An insect, *Cocytodes coerulea* Guenée attacks ramie. This large bodied insect lays its eggs on the under surface of the leaves. The larvae feed on the leaves. The insect is found throughout the year. The Ohta Development Company has placed it under control by spraying the plants with a weak solution of lead arsenate.

Uses. Ramie fiber is made into thread, string, fish nets, cloth, and sacks. Yarns from ramie fiber have been used in the manufacture of incandescent gas mantles in the United States and France. In Japan and China, the fiber is used for the manufacture of fabrics similar to United States linen, fish lines, laces, mosquito nets, and summer clothing. The tensile strength of the ramie fiber is much lower than that of the abacá fiber.

Market for ramie fiber. Japan is the best market for ramie fiber. She buys 60 to 80 per cent of the total exports from ramie producing countries like China, Formosa, and to a limited extent, India. According to the managers of the Ohta Development Company and Furukawa Plantations, Japan imports from China six to eight millions yen worth of ramie fiber every year. The lowest price for which they have sold ramie fiber was ₱12.00 per picul, and the highest, ₱25.00.

SUMMARY

1. Ramie, or China grass, *Boehmeria nivea* (Linn.) Gaudich. is a well-known fiber plant. It is now extensively cultivated as an export crop by two Japanese companies in Davao.
2. The variety of ramie grown in Davao, the climatic requirements of the crop, the method of culture, preparation of the fiber, cost of production, yield, pests, uses, and market for the fiber are described briefly in this paper.

A STUDY ON THE EFFECT UPON GROWING PIGS OF MIXING VARYING AMOUNTS OF WATER IN THEIR GRAIN RATIONS[1]

Celestino B. Quilang

Feeding hogs with slop is a general practice the world over. Yet, little or no attention has been given to the amount of water to mix with the feed to form the slop. The lack of literature seems to imply that the amount of water to add to the feed makes little or no difference. It seems obvious, however, that the same feed given in slop with varying amounts of water is likely to change the bulk if not the character of the feed with a corresponding effect on the pigs.

In slop feeding, thin, thick, and medium are used to describe the consistency of the feed. The amount of water added to the grain ration for all classes of hogs seems to be affected by the availability of the feed. When the feed is not sufficient, hog feeders tend to limit the amount of grain used and to make up the deficiency by the addition of water to the volume of slop required to fill the pigs. In times of abundance more feed is given and less water is added to make the volume of slop needed by the pigs. As it is not known whether or not the amount of water added to the feed makes any difference, this study was conducted in order to throw some light on this question of swine feeding.

Review of literature

According to Henry and Morrison (1917) Plumb and Van Norman found that it made no difference whether one or three pounds of water per pound of meal was used to form the slop. Good and Smith (1930) found that when dry ground wheat is fed to pigs, it often gums up in the mouth and forms a pasty mass which is difficult to masticate and swallow. Feeding ground wheat as a thin slop, however, overcomes the trouble.

The Oregon Agricultural Experiment Station in its biennial report (1929-1930) describes feeding experiments on swine showing that in a pig ration water varying from one to four pounds to one pound of grain did not materially affect the rate or economy of gain. The crude fiber content of a ration apparently had a greater influence on the utilization of low grade wastes than did water content.

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The Kansas Agricultural Experiment Station (1909) reported that as much pork can be made from a stated amount of feed given either in dry or in wet form provided an abundance of drinking water is supplied.

Object of this study

The object of this study was to determine the effect upon growing pigs of feeding slops of the same ration mixture with varying amounts of water added to form the slops.

Time and place of this study

The experiment, divided into three seventy-day periods, was started on June 24, 1934, and closed on January 21, 1935. It was conducted in the Swine Husbandry Division of the Department of Animal Husbandry, College of Agriculture, Los Baños, Laguna.

MATERIALS AND METHODS

Animals. Twenty-four Berkjala weanling pigs about ten weeks old at the beginning of the experiment were used. They were fairly uniform in size and condition.

Feeds. The feeds used were corn, rice bran, copra meal, and fish meal. The proportions by weight of the feeds used were as follows:

Ration mixture	*First 70-day period* I	*Second 70-day period* II	*Third 70-day period* III
Corn	15	20	25
Rice bran	60	60	60
Copra meal	18	16	13
Fish meal	7	4	2
Total	100	100	100
Nutritive ratio	1:4.1	1:4.8	1:5.4

(Based on chemical analysis only)

The average prices of the feeds used at the time of the feeding trial were:

Corn	4	centavos	a	kilogram
Rice bran	3	”	”	”
Copra meal	3	”	”	”
Fish meal	11	”	”	”

To every 100 kilograms of the feed mixture used, one kilogram of mineral mixture consisting of equal parts of common salt and of corn cob charcoal was added.

Allotment of pigs. The twenty-four weanling pigs were divided into four lots of six pigs each. Care was taken to have the lots as uniform as possible in sex, weight, and condition of the animals.

All lots received the same grain ration mixtures but different amounts of water to form the slops. Lot I received the slop in which the feed and water were in the proportion of 1:2; lot II, 1:3; lot III, 1:4, and lot IV, 1:5. For convenience the feed slop in lot I was designated as slop No. 1; in lot II, slop No. 2; in lot III, slop No. 3; and in lot IV, slop No. 4. Feed slop No. 1 had the consistency of a soft, doughy mass, or very thick; slop No. 2, medium; slop No. 3, thin; and slop No. 4, watery or very thin.

Feeding. All the lots were allowed all of the slop that they could readily consume. The pigs were fed twice a day, in the morning and in the afternoon. The slops were prepared immediately before each feeding.

Weighing. The initial and final weights of each pig were taken and the individual pigs were weighed weekly just before feeding in the afternoon.

Management. During the first seventy-day period, all the pigs were kept together in a yard of about 625 square meters in area but bare of vegetation. In the yard they were supplied with sweet potato vines at the rate of one kilogram per one hundred kilograms of live weight after watering at noon. At feeding time, the pigs were driven to the hog house and each of the four lots was fed separately in a different pen.

In the second seventy-day period of the test, the hogs were transferred to a new yard similar in size and condition to the field that they had occupied during the first period. They received the same care that was given to them during the first period.

In the third seventy-day period, the pigs were returned to the yard that they had occupied during the first period. At this time the pigs were not given camote soilage. During inclement weather, the animals were kept in the hog house at night.

RESULTS

The results of the experiments are presented in tables 1 and 2. The tables give the average daily consumption of slops per pig full-fed, the average grain ration contained in the slops, the feed consumed per kilogram gain of the pigs, and the cost of feed per kilogram of gain.

DISCUSSION OF RESULTS

First seventy-day period. Table 1 shows that the pigs in lot IV consumed the largest amount of slop, those in lot I, the least, and those in lots II and III intermediate between them. The pigs fed the more dilute slops seemed to eat as much as possible in order to secure more grain.

Normally pigs from two to six months old should be able to consume about five kilograms of feed per 100 kilograms of live weight, or five per cent.

The pigs in lots I, II, and III made rapid gains in weight with very little difference between each lot. This result seems to corroborate the findings of Plumb and Van Norman as reported by Henry and Morrison (1917) who stated that one to three pounds of water added to each pound of meal made no difference. The pigs in lot IV made the lowest gain probably because their feed was so dilute that the amount of grain consumed was insufficient to adequately nourish them.

On the basis of feed consumed per kilogram of gain, the pigs in lot III made the most economical gain; those in lot II, second; those in lot IV, third, and those in lot I, last. The results show that slop made in the proportion of one part of feed to two parts of water is too concentrated and that, on the other hand, one part feed to five parts water is too watery. In the cost of feed per kilogram of gain, the lots also ranked in the same order.

Second seventy-day period. Table 1 shows that the rate of gain made by the lots decreased as the grain content of the feed slops was reduced showing that there was a close relationship between the amount of feed consumed and the rate of gain. In other words the larger the amount of feed consumed by the animals the greater was the amount of gain per unit of time. In the second period the amount of feed that could be ingested was limited as in the first period by the volume and dilution of the slops. The pigs in lot IV consumed the least grain. In lot I the grain consumption per 100 kilograms of live weight of the pigs was the highest, in lots II and III, intermediate, and in lot IV the consumption was lowest.

Third seventy-day period. As in the first seventy-day period, the pigs in lot II made the greatest daily gain followed closely by those in lot I. The pigs in lots III and IV made the least daily gain.

In feed cost per kilogram of gain, lot IV continued to be the most economical. However, this was secured at the expense of rate of growth which was greatly retarded as in the previous periods.

Combined 210-day test. Table 2 shows that the pigs in lot II made the most rapid growth and development. Expressed in percentage and with the gain in weight of the pigs in lot I taken as 100 per cent, the gain in weight of the pigs in lot II was 104 per cent, those in lot III, 84 per cent, and those in lot IV, 68 per cent. Where rapid growth and well balanced development are important considerations, as in pigs intended for breeding, feeding slop in the proportion of 1 part feed to 3 parts of water, as in lot II, is the best. This lot was followed closely by the pigs in lot I which received slop prepared in the proportion of 1 part feed to 2 parts water. When the dilution was more than 1 to 3, however, as the feed in lots III and IV, the results clearly showed that the pigs could not secure sufficient grain to provide the required nutrients for their normal growth. The pigs were comparatively small, narrow in framework, spare, and paunchy.

In regard to feed consumption, the pigs in lot IV made the most economical gain in weight, but this was accomplished at the expense of their normal growth, which was greatly retarded. With economy of feed, time, overhead charges, and quality and finish of the pigs considered, the dilution of the slop in the proportion of 1:3 proved to be the most economical feed all-around. Slop prepared in the proportion of 1:2 produced about the same rate of gain as that in the proportion of 1:3. The former proportion, however, required a larger amount of feed per unit of gain than did the latter. Dilutions of 1:4 and 1:5 limited the grain ration so much that less feed was consumed per kilogram of gain. These two dilutions may be used during times of scarcity of feed.

SUMMARY AND CONCLUSION

1. Based on the rate of gain for the entire 210-day period, feed slop No. 2, medium, appeared to give the best results followed very closely by feed slop No. 1, very thick. Feed slop No. 4, very thin, markedly retarded the growth and development of the pigs.

2. Based on economy in feed, slop No. 4 gave the most economical gains, slops No. 2 and 3 were intermediate, while slop No. 1, was the most expensive.

3. When feed is scarce the proportion of the water in the feed may be increased from 1:3 to 1:4 without greatly affecting the normal growth and development of pigs. Although a further dilution

to 1:5 reduced the amount of feed required per unit of gain, it retarded the growth of the pigs. Feeding slop containing water in the proportions of 1:4 and 1:5 may be good for older animals but not for breeding pigs which require rapid and balanced development.

4. Reducing the proportion of water to 1:2 increased feed cost per unit of gain without a corresponding increase in rate of gain. A slop with a dilution of 1:3 seemed to be the best all around feed for pigs. A concentrated slop also appears to be good for younger pigs.

5. Based on the 210-day period, a pig on a slop ration of 1:2 dilution could recover 1.55 kilograms of grain; from 1:3 dilution, 1.26 kilograms; from 1:4 dilution, 1.03 kilograms; and from 1:5 dilution, 0.73 kilogram.

6. During the 210-day test the pigs ingested from 11.40 to 16.64 kilograms of slop per 100 kilograms of live weight, or 12 to 17 per cent of their weight.

7. The more dilute the slop, the greater the amount ingested by the pigs in order to obtain the required amount of grains.

8. The results of this experiment corroborate the conclusion of previous workers that slops consisting of 1 part feed and 1 part water to 1 part feed and 3 parts water made little or no difference, as long as the pigs were furnished an abundance of drinking water.

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TABLE 1

Results obtained from partial seventy-day periods

FIRST SEVENTY-DAY PERIOD

	LOT I	LOT II	LOT III	LOT IV
	kgm.	*kgm.*	*kgm.*	*kgm.*
Average daily gain per pig	0.27	0.30	0.25	0.19
Average daily ration of slops per pig	2.79	3.36	3.20	3.42
Average grain ration in slops per pig	0.93	0.84	0.64	0.57
Consumption of slops per 100 kilograms live weight	15.35	17.15	18.52	22.16
Consumption of grain per 100 kilograms live weight	5.12	4.29	3.71	3.69
Feed consumed per kilogram gain	3.44	2.80	2.56	3.00
Feed cost per kilogram gain	₱ 0.13	₱ 0.10	₱ 0.09	₱ 0.11
RESULTS FROM THE SECOND SEVENTY-DAY PERIOD				
Average daily gain per pig	0.24	0.22	0.20	0.14
Average daily ration of slops per pig	5.28	5.16	5.60	4.02
Average grain ration in slops per pig	1.76	1.29	1.12	0.67
Consumption of slops per 100 kilograms live weight	14.69	13.60	17.03	14.82
Consumption of grain per 100 kilograms live weight	4.90	3.40	3.40	2.47
Feed consumed per kilogram gain	7.33	5.86	5.60	4.79
Feed cost per kilogram gain	₱ 0.26	₱ 0.21	₱ 0.20	₱ 0.17
RESULTS FROM THE THIRD SEVENTY-DAY PERIOD				
Average daily gain per pig	0.23	0.26	0.18	0.17
Average daily ration of slops per pig	5.85	6.68	6.65	5.76
Average grain ration in slops per pig	1.95	1.67	1.33	0.96
Consumption of slops per 100 kilograms live weight	11.15	12.25	14.45	15.18
Consumption of grain per 100 kilograms live weight	3.71	3.06	2.89	2.53
Feed consumed per kilogram gain	8.45	6.42	7.39	5.65
Feed cost per kilogram gain	₱ 0.29	₱ 0.22	₱ 0.25	₱ 0.19

TABLE 2

Summary of results obtained from the entire 210-day feeding trial

	LOT I	LOT II	LOT III	LOT IV
	kgm.	*kgm.*	*kgm.*	*kgm.*
Average initial weight per pig	8.63	8.95	8.50	8.67
Average final weight per pig	60.63	63.53	52.30	43.97
Average daily gain per pig	0.25	0.26	0.21	0.17
Average daily ration of slops per pig	4.64	5.04	5.15	4.38
Average grain ration in slops per pig	1.55	1.26	1.03	0.73
Consumption of slops per 100 kilograms live weight	11.40	13.91	16.94	16.64
Consumption of grain per 100 kilograms live weight	4.47	3.48	3.39	2.77
Feed consumed per kilogram gain	6.27	4.87	4.90	4.40
Feed cost per kilogram gain	₱ 0.22	₱ 0.17	₱ 0.17	₱ 0.15

SELF-FEEDING FREE CHOICE VS. SELF-FEEDING NO CHOICE SYSTEMS OF FEEDING CORN, RICE BRAN, COPRA MEAL, AND FISH MEAL FOR MARKET PIGS[1]

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The standard swine rations in use in the College of Agriculture have been formulated by modifying recognized feeding standards for hogs in accordance with the results of experiments on Berkjala breed and grade pigs and using local feeding stuffs. Although the results from the use of these rations are satisfactory, it is probable that they can still be improved.

Review of literature

Using ten crossbred pigs from Tamworth sows sired by a Duroc-Jersey boar, Robison (1922) compared self-feeding mixed rations composed of 6 parts corn and 1 part linseed meal with self-feeding the same feeds, free choice. He noted that the pigs fed with the mixture ate a larger total amount of feed daily per unit of weight, gained 26.35 per cent more rapidly, and required 8.05 per cent less feed for each 100 pounds (45.00 kgm.) of gain produced than those given the corn and linseed meal separately. The pigs given freedom to choose their feed took only 1 part of linseed meal to 25.8 parts of corn.

The same author used two lots of four Tamworth pigs each and compared self-feeding a mixture of 5.5 parts corn and 1 part linseed meal and self-feeding the two feeds separately. From the results he concluded that feeding mixed feed produced more rapid gains and reduced the amount of feed required for each 100 pounds (45.00 kgm.) of increase in live weight.

At the same time that the present work was in progress, Eleazar (1938) compared self-feeding, without choice of feed, with hand-feeding the same ration mixtures used in the College for growing and fattening shotes. This author concluded that self-feeding, without choice of feed, was 9 per cent better in the rapidity of gains than the hand-fed lot. The self-fed lot made an average daily gain in weight of 0.38 kgm., and the hand-fed lot, 0.35 kgm. The latter consumed 1.05 kgm. more feed than the former for each kilogram gain.

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[1] Experiment Station contribution No. 1299. Prepared in the Department of Animal Husbandry under the direction of Dr. Mariano Mondoñedo.

Objects of the present work

The objects of this study were to determine: (*a*) the influence of self-feeding, free choice, and self-feeding, without choice of feed, on the economy of pork production; (*b*) whether or not the pigs can balance their own ration out of a given group of feeds such as corn, rice bran, copra meal, and fish meal; and (*c*) the consumption of feeds under the two systems of feeding.

Time and place of the work

The experiment was begun on December 2, 1934, and was closed on June 30, 1935, a period of seven months. It was conducted in the Department of Animal Husbandry of the College of Agriculture at Los Baños.

MATERIALS AND METHODS

Animals used. Twelve Berkjala weanling pigs which were about 15 weeks of age at the beginning of the experiment were used.

Self-feeders. The self-feeders used were 1.0 meter high, 1.7 meters wide, and 0.5 meter deep; they were divided into five compartments each.

Shelter. A temporary cogon shed, about six meters long and three meters wide, was built to provide shelter for the pigs. The shed was divided in the middle by the fence that separated the pasture of lot I and lot II.

Feeds used. The feeds used and the price per kilogram of each at the time of the experiment were as follows:

Corn	8.20 centavos per kgm.
Rice bran	3.08 centavos per kgm.
Copra meal	3.60 centavos per kgm.
Fish meal	11.00 centavos per kgm.

Mineral mixture used. The mineral mixture used consisted of 50 parts common salt and 50 parts wood charcoal. To every 100 kilograms of the feed mixture used in lot I, two kilograms of the mineral mixture, or two per cent, were added. Lot II was given access to the same mineral mixture in a separate compartment of the self-feeder. A kilogram of the mineral mixture costs 4.7 centavos.

Allotment of pigs. The pigs used in this experiment were divided into two lots of six pigs each. Care was taken that the two lots were as uniform as possible in sex, size, and condition. The control lot was designated as lot I, self-fed, without choice; and lot II, self-fed, with free choice of feed.

Feeding. Each lot was provided with a self-feeder. Lot I was self-fed with the following ration mixtures:

	First 70-day period	*Second 70-day period*	*Third 70-day period*
Corn	15 parts by weight	20 parts by weight	25 parts by weight
Rice bran	60 ” ” ”	60 ” ” ”	60 ” ” ”
Copra meal	18 ” ” ”	16 ” ” ”	13 ” ” ”
Fish meal	7 ” ” ”	4 ” ” ”	2 ” ” ”
	100	100	100

Lot II was allowed free choice of corn, rice bran, copra meal, and fish meal, which were placed separately in the compartments of the self-feeder. The pigs in each lot had access to the feeds in the self-feeder at all times. During the first 70-day period cracked corn was used in both lots. In the second and third 70-day periods shelled corn was used.

Duration of the experiment. The work was carried out for 210 days, divided into three 70-day periods.

Weighing. Initial, final, and weekly weights of each pig were taken.

CARE AND MANAGEMENT

The pigs in both lots had free access to camote pasture and to the self-feeders at all times. Inspection of the self-feeders was made morning and afternoon, to see that the feed in each compartment of the self-feeders was available to the pigs all the time. During the rainy season, the feeds in the self-feeders were stirred because they did not flow into the trough freely, owing to absorption of moisture. Every Sunday between two and three o'clock in the afternoon, the pigs were driven to the hog barn and weighed. The feeds placed in the self-feeders were also weighed. To determine the weekly feed consumption of the pigs, the portion that was left at the end of the week was weighed and recorded.

Wooden drinking troughs with wooden bars nailed crosswise and spaced close enough to prevent the pigs from wallowing but wide enough to allow them to drink conveniently were used. Clean water was run into the troughs two or three times a day, providing sufficient water all the time. Owing to hot weather, it was necessary to bathe the pigs once or twice a day during the middle part of the second period of the experiment. Towards the end of the first period, the camote pasture was exhausted. During the second and third 70-day periods camote soilage at the rate of one per cent of the total live weight of the pigs, as determined weekly, was given to both lots between four and five in the afternoon.

RESULTS

The results obtained in this study are summarized in tables 1 and 2. Table 1 shows (1) the amount of feed consumed daily per pig and the feed consumed per unit of live weight, (2) rate of gain, (3) feed consumed per unit of gain, and (4) cost of feed per unit of gain. Table 2 shows the proportion of the constituents of the rations consumed by lots.

DISCUSSION OF RESULTS

First 70-day period

Before the pigs were used in the experiment, they were on grain-soilage system of feeding. During the first week of the experiment, the pigs in lots I and II tended to forage on the succulent young stems, leaves, and roots of the sweet potato. They did considerable rooting and digging in the camote patch early in the morning and at about four or five o'clock in the afternoon. Perhaps partly because of this the pigs consumed less feed per kilogram gain than in the succeeding weeks. The camote pastures of both lots were depleted before the end of the period. The pigs in lot I (self-fed, without choice) ate their feed with relish, and those in lot II (self-fed, with free choice) relished the corn and rice bran more than the other feeds placed before them.

During the first week the pigs in lot II hardly touched the copra meal but ate the corn, rice bran, and fish meal readily in the order named. In the fifth week the pigs began to consume more of the copra meal than during the early part of the period. The consumption of corn increased considerably.

Table 1 shows that the animals in lot II made an average daily gain of 0.07 kgm. per pig or 17.5 per cent more than those in lot I. This difference may be due to the fact that the pigs in lot II consumed a larger amount of the ration than those of lot I, probably because they could feed frequently and selected the feeds that they liked best. Of the corn, the pigs in lot II consumed 3.7 times as much as the pigs in lot I were able to get from their mixed ration. The pigs in lot II consumed a relatively small amount of rice bran.

It may be noted that the pigs in lot II consumed twice as much fish meal as did those in lot I but very little copra meal. This was expected because fish meal is much more palatable than copra meal.

Considering the quantity of feed required to make a kilogram of gain, it was noted that the pigs of both lots consumed about the same amount of feed. In regard to the cost of feeds consumed, however, it was found that for every kilogram of gain made by the pigs of lot I, the feed cost 7.81 centavos less than that of the animals in lot II. The high cost of feed for obtaining the gains in lot II was largely due to the increase in the amount of corn and fish meal, both of which are more expensive than rice bran and copra meal.

In regard to feed consumed per 100 kilograms of live weight it was noted that the pigs fed on the self-feeding, free choice system were more extravagant than those raised on self-feeding system without choice of feed.

The nutritive ratio of the ration in each lot during the experiment hardly had any difference; it was 1:5.00 for lot I and 1:4.94 for lot II.

Second 70-day period

The pigs in both lots continued to be in good condition. They were either eating from the self-feeder, grazing, or lying down under the shed or in the open independently of each other. When the weather was hot and during stormy days they were lying down together under shelter.

The pigs in lot I appeared to masticate their feeds more thoroughly than those of lot II because their feces was normal. During this period lot I made an average daily gain of 93 per cent per pig more than the pigs in lot II. The failure of the pigs in lot II to make a better gain than the pigs of lot I, as they did in the first 70-day period, could not be easily ascertained. Shelled corn was given during this period because the pigs were sufficiently old and vigorous to chew the kernels. It was noted, however, that in the pigs of lot II some of the corn kernels were passed out undigested. As the second 70-day feeding period was carried out during the dry season green grass and camote vines were scarce. Because of the large amount of corn that they consumed, the pigs in lot II, appeared markedly fatter and more affected by the heat than the pigs of lot I.

During the second period neither lot made as large gains in weight as they did during the first period. Eleazar (1938) noted the same result in both lots of his pigs. The decrease of the rate of gain was probably due to the weather which affected the pasture and the health of the pigs. The first 70-day period was carried out during the cool months of December and January, and at this time a sweet potato pasture was available to the animals. During the second 70-day period the weather was dry; so pasturage was poor.

In regard to the amount of feed needed to make a kilogram of gain, lot II required 12 per cent more feed than lot I. To make a kilogram gain lot II consumed 16.19 centavos more feeds than lot I. The big difference in the cost is again due mainly to the larger amount of corn consumed and to the larger total amount of feed eaten by the pigs in lot II.

The nutritive ratio of the feed of lot I was 1:5.7 and that of lot II was 1:6.8. Because of this difference in the nutritive ratio of the feeds the pigs in lot II were distinctly fatter than those in lot I.

Third 70-day period

The pigs in lot I continued to be more active than those in lot II. They ate the feed in the same manner as they did in the second 70-day period. All of the pigs in both lots were healthy except for the lameness of pigs Nos. 2588 and 2618 in lot II for a few days beginning May 25, 1935. As in the second 70-day period the pigs in lot II voided undigested corn.

In the third period, lot I was 90 per cent more efficient than lot II. The cost of feed to make the same amount of gain was 20.91 centavos more in lot II than in lot I. The increase in the feed cost to make a kilogram of gain in lot II was again largely due to the fact that corn constituted about 78 per cent of the total feed. In lot I, the corn consumed was only 25 per cent of the mixture.

The nutritive ratio of the feed in lot I was 1:6.5 and that in lot II, 1:8.1. Due to this difference in the nutritive ratio, the pigs in lot II were again markedly fatter than those in lot I. The pigs in lot II appeared to have matured and assumed a satisfactory degree of finish for slaughter earlier than the pigs in lot I.

The 210-day feeding trial

Taking the three feeding trials as a whole, the most notable result obtained was the economy of feed for a given unit of gain in lot I. For a kilogram gain in weight, lot I consumed 13.77 centavos or 70 per cent less than that of lot II. In the rate of gain, however, both lots were about the same. Similar results were observed by Robison (1922).

The results show that, when pigs are on the self-feeding, free choice system, it is not advisable to give side by side corn and rice bran as basal feeds and copra meal and fish meal as protein supplements. This is due to the fact that the animals will take the more palatable feeds regardless of cost.

The pigs in lot I and lot II consumed about the same amount of feed per pig daily. The animals in lot I consumed 3.16 kgm. of the ration per 100 kgm. of live weight, and those in lot II, 3.39 kgm. without a corresponding increase in the rate of gain. With the rate of gain in the two lots about the same, the self-feeding, without choice of feed, was more economical than the self-feeding, with free choice system.

The nutritive ratio based on chemical analysis of the feed in lot I was 1:5.8 and in lot II, 1:6.6. Owing to the wider nutritive ratio the pigs in lot II appeared to be in better finish than those in lot I.

SUMMARY AND CONCLUSIONS

The results of a study comparing self-feeding with free choice and self feeding without choice systems of feeding pigs using corn, rice bran, copra meal, and fish meal are reported in this paper. From the results obtained the following conclusions may be drawn:

1. With the whole feeding trial taken as one experiment of 210 days duration, from the point of view of rapidity of gain, these two systems of feeding gave about the same results.

2. Based on the amount of feed consumed to make a kilogram gain for the whole period, the self-feeding with free choice was only 93.92 per cent as efficient as the self-feeding without choice.

3. From the standpoint of feed cost for each kilogram gain in live weight for the whole feeding test, the pigs self-fed without choice required feeds costing 19.61 centavos, while those self-fed with free choice consumed feeds costing 33.38 centavos.

4. Under the self-feeding without choice system the average consumption of feed per 100 kilograms of live weight was 3.16 kgm. and those on self-feeding with free choice system, 3.39 kgm.

5. The pigs raised on self-feeding without choice system of feeding appeared to be more uniform in development than those on self-feeding with free choice system. However, the pigs on self-feeding with free choice were more blocky and better finished.

6. The pigs on the self-feeding with free choice system had the tendency to balance their ration. However, it is not advisable to raise pigs on this system with corn, rice bran, copra meal and fish meal as feeds because the more palatable feeds are consumed in greater quantities than the others without regard to cost.

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TABLE 1

Summary of results of the experiment

	LOT I SELF-FED NO CHOICE	LOT II SELF-FED FREE CHOICE
First seventy-day period		
Average daily gain in kgm.	0.40	0.47
Average daily consumption per pig in kgm.	1.16	1.40
Average daily consumption per 100 kgm. live weight in kgm.	4.46	4.91
Feed consumed per kgm. gain	2.90	2.95
Cost of feeds per kgm. gain in centavos	13.05	20.86
Second seventy-day period		
Average daily gain in kgm.	0.40	0.38
Average daily consumption per pig in kgm.	1.74	1.87
Average daily consumption per 100 kgm. live weight in kgm.	3.21	3.20
Feed consumed per kgm. gain	4.32	4.92
Cost of feeds per kgm. gain in centavos	19.48	35.67
Third seventy-day period		
Average daily gain in kgm.	0.33	0.31
Average daily consumption per pig in kgm.	1.98	2.11
Average daily consumption per 100 kgm. live weight in kgm.	2.48	2.55
Feed consumed per kgm. gain	6.06	6.72
Cost of feeds per kgm. gain in centavos	27.81	48.72
Combined two hundred ten-day period		
Average initial weight in kgm.	11.93	11.87
Average final weight in kgm.	91.13	93.61
Average daily gain in kgm.	0.38	0.39
Average daily consumption per pig in kgm.	1.63	1.79
Average daily consumption per 100 kgm. live weight in kgm.	3.16	3.39
Feed consumed per kgm. gain	4.31	4.61
Cost of feeds per kgm. gain in centavos	19.61	33 38

TABLE 2

Proportion of feeds consumed by lots [a]

FEEDS	FIRST 70-DAY PERIOD		SECOND 70-DAY PERIOD		THIRD 70-DAY PERIOD		210-DAY PERIOD COMBINED	
	Lot I Self-fed no choice	Lot II Self-fed free choice	Lot I Self-fed no choice	Lot II Self-fed free choice	Lot I Self-fed no choice	Lot II Self-fed free choice	Lot I Self-fed no choice	Lot II Self-fed free choice
Corn	15	56	20	72	25	78	21	70
Rice bran	60	26	60	18	60	17	60	19
Copra meal	18	4	16	4	13	3	15	4
Fish meal	7	14	4	6	2	2	4	7
Total	100	100	100	100	100	100	100	100
Nutritive ratio [b] ..	1:5.0	1:4.9	1:5.7	1:6.8	1:6.5	1:8.1	1:5.8	1:6.6

[a] Proportions are in parts by weight.
[b] Based on chemical analysis.

TRAVEL NOTES ON ORIENTAL NEIGHBORS[1]

VALENTE VILLEGAS
Of the Department of Animal Husbandry

Through French Indo-China, from Saigon to Pnompenh, Cambodia, rice lands lie on both sides of the road with large plantations of rubber in places favorable for this crop. Numerous fields of tobacco grow on this rice land irrigated by water from wells. Saigon is the chief seaport of French Indo-China, which together with Cholon, a suburban town, has a population of 325,000.

To the southwest is the Kingdom of Cambodia, a French protectorate. Throughout the country, extensive areas of rice, corn, and kapok trees strike the attention of the traveler. Here one finds an abundance of the palmyra palm (*Borassus flabelliformis*) which furnishes the people with their sugar supply. Large numbers of cattle and carabaos roam over the fields although none of these may be classified as range animals. The Mekong River, originating from Laos and from a lake in the west central part, crosses the country towards Cochin China and from this come various kinds of fresh-water fish which constitute an important food in Cambodia. On account of the sparse population, large forests still exist especially in the southwest. Lumbering is, therefore, another major industry here.

The principal roads of Cambodia are surfaced with asphalt running straight for a long distance on the plain. Another means of travel is by the Mekong River and its tributaries. To those who may wish to see Angkor Wat, one of the wonders of the world, the trip from Saigon is made with a stop-over at Pnompenh.

From Angkor the traveler crosses the Kingdom of Siam as he makes his way towards Bangkok, the capital. On the central plain of Siam and towards the east, the characteristic scenery is one of extensive areas of irrigated rice land. Owing to the low topography of the country, large artificial canals, known as "klongs", have been dug for the purpose of irrigating rice fields. At the same time, these "klongs" serve as a means of communication by motor or sail boats.

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[1] General contribution from the College of Agriculture No. 681. Address delivered by the writer at the opening exercises of the College of Agriculture, on June 2, 1938.

Rice is the main crop of Siam. This country vies with French Indo-China in the value of export rice; Burma, however, leads them. Forest products constitute an important source of wealth of the country, teak being exported in large quantities. In the south are tin mines and rubber, the two other leading products of Siam. Fish from the sea, rivers, and "klongs" help reduce the cost of living in Siam.

Siam does not have a good road system except in the south and in the north and northeast. Its railway system, however, is very well developed. Rest houses in important towns reached by the railroad have been built to encourage traveling.

Photo courtesy Mr. G. Vega

Central market at Pnompenh, Cambodia.

Bangkok is one of the attractions of the Orient. It is a city of 681,214 people. A number of canals cross the city, only by means of which, in former times, traveling was made possible. Sometimes, it is referred to as the "Venice of the Orient". Even now the use of taxi boats is common and is an interesting experience for the newcomer. In the Menam Chao Phya one sees true riverlife, with its floating stores where the owners live and rear their families from generation to generation.

Malaya is in the southern portion of the Kra peninsula, between Siam and Singapore. It includes the colony of the Straits Settlements, the Federated Malay States, and the Unfederated Malay States. The Straits Settlements comprise Singapore Islands, Penang Island, Cocos Island, Christmas Island, Province Wellesley, Malacca, and Labuan; the Federated Malay States, Perak, Selangor, Negri Sembilan, and Pahang; and the Unfederated Malay States, Johore, Kedah, Perlis, Kelantan, Trengganu, and Brunei on the Island of Borneo. The total area is 150,211 square kilometers.

The important cities in Malaya are Singapore, Penang, Kuala Lumpur, Ipoh, Taiping, Malacca, and Seremban. All, except Malacca, are on the main railway line from Siam to Singapore. Singapore and Georgetown (inaccurately called Penang) are the largest of these. The inhabitants are mostly Chinese, Malays and Indians. From the north to the south, whether one is traveling by train or by automobile, the traveler sees solid plantations of rubber, interspersed only by rice fields in the lowland or by tin mines. Coconuts are grown on the seacoast and on the banks of rivers. In the State of Johore, near Singapore, there are large plantations of African oil palm (*Elaeis guineensis*) and wide areas of pineapple for canning purposes.

Ceremonial practice at Palace Ground before planting season in Pnompenh, Cambodia

Malaya has an even better railway system than Siam. Alongside the railroad are good highways extending from Siam to Singapore. There are three holiday resorts in Malaya, one at Maxwell

Hills, the other at Cameron Highlands, and the third at Fraser's Hill, all rising about four to five thousand feet (1,200 to 1,500 meters) above sea level. The traveler may readily reach these places from the railroad stations nearby.

In my travels, my greatest difficulty was with the language in French Indo-China. Only a few persons speak English in this country, even among the employees of the leading hotels. In Siam, English is spoken by the officials and students. Of course, in Malaya, English is spoken generally, the Indians being more fluent than the Chinese or Malays.

Traveling over the mainland in Cambodia and Siam during summer is a trying experience on account of the heat. As one goes through Malaya, however, owing to the presence of two large bodies of water on each side, the climate is more agreeable and is like that of the Philippines.

As regards agricultural education, one may feel quite proud that among the countries visited the Philippines stands alone in having a College of Agriculture offering collegiate instruction. French Indo-China and Malaya have schools of agriculture which in the words of an official were organized partly to supply these countries with "recruits for junior appointments in local government agricultural services". In French Indo-China, at the time of this visit, it was claimed that the schools of agriculture and veterinary medicine had to be closed because there were no longer positions for their graduates in the government. The School of Agriculture in Malaya at Serdang was established in 1931 with a capacity for only eighty students. In Siam, while agricultural courses are still non-collegiate in standing, a college of agriculture will soon be opened at Bangkhane.

Agricultural education in Siam starts after finishing the elementary grades called *Prathom*. The pupil enrolls in the two-year agricultural course at the completion of which he is considered better equipped for farming as a vocation. If a student takes agriculture after finishing the intermediate grades, called *Madhayom*, he may matriculate in the two-year elementary agricultural teacher training course to qualify as a teacher, or *Prayok Kru Mul Kasikam*, in the two-year agricultural course for practical farmers. For advanced education, a student may choose to pursue the four-year agricultural high school curriculum at the end of which he may take farming for his life work. If he desires to become a teacher in the elementary teacher training course, he may take two years more of study leading to the title of *Prayok Kru Prathom Kasikam.* A graduate holding the certificate of *Prayok Kru Mul Kasikam* can also work for the title *Prayok Kru Prathom Kasikam* by taking identical subjects. Further improvement in agricultural education may be acquired by self study, and an opportunity for promotion is afforded through competitive examinations given by the Ministry of Public Instruction. Those who qualify by this examination are entitled to teach in the four-year agricultural high school course as *Prayok Kru Madhayom Kasikam.* a rank midway between our Associate in Agriculture and Bachelor of Science.

Photograph by Dr. R. L. Pendleton

Elephants are an important means of transportation in Northern Siam.

Siam recognizes the standing that our College of Agriculture enjoys among similar institutions of learning in the world. When the writer called on the Ministry of Agriculture and Lands, one of the questions of the Minister was "Which other colleges in the University of the Philippines are class A-1 like your College of Agriculture?" It is, therefore, not surprising that Siam has been sending a big quota of its students to this College since the days of Eang Chandrasathitya, Thongdee Resananda and Chuang Lochaya.

The alumni and former students of this College are acquitting themselves creditably in Siam. Three key positions in the Department of Agriculture and Fisheries are held by them. I have reference to Luang Suwan (Thongdee Resananda), Technical Director, and Luang Ing (Eang Chandrasathitya), Director of Experiment Stations. Phra Chuang Kashetra Silpakara (Chuang Lochaya), Acting Director General of the Department of Agriculture and Fisheries, was a former student of this College. All other alumni of this College are occupying important technical positions in the government service. Mr. Charoon Suebsaeng is Secretary to the Minister of Agriculture and Lands. I should not fail to mention Dr. R. L. Pendleton, formerly Head of the Department of Soils of this College, who is now Adviser in the Department of Agriculture and Fisheries. There are two Filipino graduates holding responsible positions in the Siamese government: Mr. Magdaleno Cero, soil technologist and chemist, Department of Science, and Mr. Virgilio Bustos, sugar technologist in the newly established sugar central at Lampang. Until recently, Mr. Marcelino Canlas was connected with the Department of Agriculture and Fisheries.

Agricultural science is extended to the people through its various experiment stations. These are the Central Experiment Station at Bangkhane, the Rice Experiment Station at Rang Sit, the Northeast Experiment Station at Nonwat, the Experiment Station at Chiengmai, the Southern Experiment Station at Haad Yai, the Cotton Experiment Station at Swankaloke, the Pepper Experiment Station at Chandaburi, and the Cattle Station at Tai Badan.

The two leading experiment stations are those at Chiengmai and at Haad Yai. The station at Haad Yai was developed by two alumni of our College of Agriculture, Luang Suwan and Thuan Komkris, the present superintendent. With a mountain similar to our Maquiling close by, Haad Yai Experiment Station brings to mind the College of Agriculture transplanted to Siam. The hog barns and poultry houses of our Department of Animal Husbandry have been reproduced at this station with but minor modifications. The Los Baños Cantonese and Nagoya fowls imported from Los Baños some four years ago are doing well in this station.

In Malaya, technical work in agriculture started in 1905 with the organization of the Department of Agriculture for the Federated Malay States having its headquarters at Kuala Lumpur. In 1918, the services of the Department were extended to the Straits Settlements. Advisory assistance is also given to the Unfederated Malay States.

The Department consists of the Research Branch and the Field Branch. Under the Research Branch are the Divisions of Agriculture, Chemistry, Copra Investigations, Entomology, Mycology, Soils, and Plant Physiology. The Field Branch is concerned with experimental, extension work, and pest and disease control. There is also the Economics and Publication Branch which has charge of agricultural statistics. The fourth branch is the Agricultural Education Branch conducting the School of Agriculture at Serdang.

The Central Experiment Station is located at Serdang, Selangor. A stock farm is part of this station. There is a dairy and a poultry farm at Fraser's Hill. The Coconut Experiment Station is at Klang, Selangor. Tea and upland crops are planted at the Experiment Station at Cameron Highlands. A Pineapple Experiment Station is also maintained in Singapore. Five Paddy Rice Experiment Stations are kept with additional test-plot stations. Besides, there are other experiment stations scattered throughout Malaya.

Through research and effective extension work, the English officials in charge of agricultural work in Malaya have done much to bring this country into a high state of cultivation that characterizes all commercial plantations established throughout the Peninsula. The use of budded rubber plants, cover crops, drainage canals, the methodical system of laying out plantations—all give the traveler the impression that behind all these is an efficient organization that helps to produce the maximum output at a minimum cost.

IN MEMORIAM: EMMA SAREPTA YULE[1]

Miss Emma Sarepta Yule, professor of English emerita, University of the Philippines, died in Los Angeles, California, April 16, 1939.

Professor Yule served in the Philippines for twenty-six years, twenty of which were spent in this College. She came to the Islands in 1910 as a teacher of Philippine economics in the Manila High School. In 1914 and 1915 she helped organize the school system in the Department of Mindanao and Sulu under special appointment from the Bureau of Education. In January, 1916, she was called to the professorial chair in English in the College of Agriculture, where she formally organized its present English Department. Her many extra-curricular activities included assistant editorship of *The Philippine Agriculturist* from 1919 to 1925 and editorship from 1925 to 1936. In addition she was a most valuable literary adviser for faculty and students alike.

When she came to the Philippine field she had a background of years of pioneering assignments along educational lines in the United States and Alaska. She began teaching as a fresh college graduate in northwestern Iowa, her native state, where she established a normal school course in an academy. Her unusual ability soon attracted the attention of James J. Hill, the railroad magnate, who drafted her to help establish schools in the western termini of his railroad system. Hence, the scene of her American activities shifted in succession, first, to a new industrial townsite in Puget Sound, then to a young settlement in Everett, Washington, and to Juneau, Alaska, a new boom town, in which places she established school systems. She was the first superintendent of schools in Everett, and quite recently a monument was erected there in her honor, a distinction accorded few persons during life. The school she established in Juneau was on the accredited list of the University of Washington in the record time of four years.

Miss Yule was a born teacher, not a pedagogue. More than merely interested in the subjects she taught, she was keenly interested in the welfare of students during and outside class hours. During her residence on the campus her home was the meeting place of young people, who found in her a second mother, adviser, and friend. Among her colleagues she was most congenial and helpful. Despite her important rôle in helping the members of the college community mould their scientific and other writings into shape that would make easy English reading, she was very modest and self-effacing. Miss Yule was one of the most beloved and respected inhabitants of the College campus.

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[1] General contribution from the College of Agriculture No. 682.

L. B. UICHANCO
Dean

COLLEGE AND ALUMNI NOTES

Shortly after the appointment of President Jorge C. Bocobo of the University of the Philippines to the cabinet as Secretary of Public Instruction on April 14, 1939, Dean Bienvenido M. Gonzalez was elected President of the University of the Philippines by the Board of Regents at a special meeting presided over by President Quezon on April 20, 1939. The following day, President-elect Gonzalez was sworn into office by the President of the Philippines.

On April 26, 1939, less than a week after President Gonzalez assumed his new duties, he announced to the faculty and student body of the College of Agriculture the appointment of Doctor Leopoldo B. Uichanco, professor and head of the Department of Entomology, as Acting Dean of the College of Agriculture, effective on April 27, 1939.

The faculty and employees of the College of Agriculture had a dance in the evening of May 3, 1939, at the Seniors' Social Garden in honor of President and Mrs. Bienvenido M. Gonzalez and Acting Dean and Mrs. Leopoldo B. Uichanco.

The following members of the faculty delivered lectures at the Fifth Alumni Institute held in the University of the Philippines, Manila, during the period from March 24, 1939, to April 1, 1939: Dean B. M. Gonzalez, on problems of economic adjustment for the Philippines; Dr. Dionisio I. Aquino, on how we should maintain the fertility of our soils in the Philippines; Dr. F. M. Sacay, on objectives and methods of vocational education; and Dr. Miguel Manresa, on the influence of temperature on various breeds of cattle.

The fourth University of the Philippines faculty conference was held in Baguio from April 12 to April 20, 1939. The College of Agriculture had the following delegates: Dean B. M. Gonzalez, Drs. L. B. Uichanco, M. Manresa, R. B. Espino, A. I. de Leon, and J. M. Capinpin, and Professors M. A. Roa, E. Fraser, R. M. Mack and T. Buenaventura. Dean B. M. Gonzalez read a paper on rules of scholarship for elimination of students on April 17, 1939. Dr. Uichanco, alternately with Dean A. G. Sison of the College of Medicine, presided over the sessions.

Officers for the current year, 1939-1940, of the SAR (Society for the Advancement of Research) are: Dr. A. L. Teodoro, president; Dr. L. G. Gonzalez, vice-president; Dr. F. M. Salvoza, secretary; and Dr. S. M. Cendaña, treasurer.

The Los Baños Biological Club likewise has for officers during the current term, Dr. J. M. Capinpin, president, and Dr. F. M. Salvoza, secretary.

Dr. D. I. Aquino, acting head of the Department of Soils, left for Cotabato and Davao on March 25, 1939, to join the soil survey party of the Bureau of Science doing reconnaissance work in Mindanao. Dr. Aquino was fortunate in being able to join in addition the party of Secretaries Alunan and Aquino which visited the Resettlement Project at Dadiangas, and that of the Bureau of Forestry which was engaged in land classification work in north Koronadal, both at Cotabato. He also visited the Agricultural High School at Upi and the Maridagao Rubber Plantation which is being managed by an alumnus of the College, Mr. F. D. Luistro. Doctor Aquino returned to the campus on April 28, 1939.

The Secretary's Office reports that the following College of Agriculture students received degrees on April 4, 1939:

Bachelor of Science in Agriculture

1. Florentino L. Apostol
2. Justo M. Bensan
3. Cornelio S. Binoya
4. Jose R. Cayabyab
5. Domiciano J. Clemente
6. Dominador C. Cueto
7. Severino M. Hermosura
8. Angel S. Huertas
9. Arsenio G. Juan
10. Ian Khambanonda, *cum laude*
11. Victor U. Luis
12. Prasert Na Nakara
13. Manuel V. Quisumbing
14. Xom Raktakanistha
15. Aniceto O. Rollan
16. Fidel M. Romakin

17. Ignacio B. Sacdalan
18. Fidel Y. Silva
19. John S. Tabor, Jr.
20. Jose P. W. Tantoco
21. Mateo R. Tibay
22. Ascario G. Tuason
23. Dioscoro L. Umali

Bachelor of Science in Sugar Technology

1. Teofilo R. Ancheta
2. Isidro S. Macaspac, *Baker scholar*
3. Pradip Pradipasen
4. Jose P. Zaldivar

Certificate in Agricultural Education

1. Andres M. de la Cruz, B.S.A.
2. Norberto P. Diaz, B.S.A.
3. Modesto M. Ragat, B.S.A.

Associate in Agriculture

1. Felipe P. Barile
2. Loredo C. Jamandre
3. Edmundo O. Obias
4. Silverio L. Soberano

Professor H. L. Richards, acting head of the Department of English, sailed in March for the United States on special detail to take up courses in the University of California. She is expected to be back by the second semester.

The seventh Rural Life Institute was held at the College from May 8 to 13, 1939, with Dr. N. B. Mendiola, head of the Department of Agronomy as Director. Twelve registrants, all of whom are religious workers from different parts of the Philippines, attended the sessions. Lectures were delivered by the following: Dr. P. A. David, on suggestions for diversification of Philippine crops; Dr. V. C. Calma, on raising fruits for home consumption and for profit; Dr. F. M. Fronda, on poultry raising; Dr. S. M. Cendaña on fish problem for rural inland communities and how it may be solved; Dr. N. B. Mendiola, on preparation of industrial articles from crop products and also on suggestions on Filipino ornamental gardens and plants; Dr. P. N. Mabbun, on possibilities of cooperatives; Mr. V. M. Dawis, on raising of vegetables; Prof. A. B. Catambay, on some suggestions about farm and garden implements; Dr. M. Mondoñedo, on preservation of pork; Dr. G. O. Ocfemia, on control of Philippine crop diseases; and Dr. F. O. Santos, on balanced diet of Filipino foods.

BIENVENIDO MARIA GONZALEZ, Sc.D.
President, University of the Philippines

PRESIDENT GONZALEZ [1]

Dr. Bienvenido Maria Gonzalez was called to the presidency of the University of the Philippines on April 20, 1939. For the first time in the history of the institution an alumnus was placed at its head. President Gonzalez's connection with the University has been of some twenty-nine years' duration. He transferred to the College of Agriculture from the Philippine Normal School as a sophomore in 1910 and graduated with the degree of Bachelor of Agriculture in 1913. He was granted the degree of M.S. by the University of Wisconsin in 1915 on his first trip as a Government student in the United States and Sc.D. by the Johns Hopkins University in 1923, on his second. From 1918 to 1921 he served as the first alumnus regent of the University of the Philippines.

As the first adequately trained faculty member in animal husbandry, he had the task in 1916, after his return from the University of Wisconsin, of organizing the Department of Animal Husbandry in the College of Agriculture. That the project was to be beset from the beginning with unforseen, although at times humorous, obstacles may be gleaned from the fact that the then President Ignacio Villamor, in response to Instructor Gonzalez's request for farm animals to stock the department, offered a few discarded skeletons from the College of Veterinary Science. Undaunted, the young instructor went ahead with his plans; the result was that the Department of Animal Husbandry not only grew into one of the biggest departments of the College but also one of the most prolific in research and student output. Within a relatively few years its scientific findings were providing a reliable basis for local instruction and, what is more, the first concrete point of departure for work on adaptability of breeds of domestic animals to Philippine and other tropical conditions. Hitherto, attempts at improving the live stock in the tropics had been pegged on the introduction of standard temperate-country breeds. Common sense deductions based on past experiences soon convinced Professor Gonzalez and his associates in the department that approach to the problem through this method, in addition to being very costly, is inherently fallacious in view of the fact that animal breeds

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[1] General contribution from the College of Agriculture No. 684.

THE PHILIPPINE AGRICULTURIST, VOL. XXVIII, No. 2, JULY, 1939.

geared to colder climates quickly sicken and die in the tropics. The sequel of this reasoning was a reorientation of research efforts in the way of creating, for the first time in the Philippines, differently styled, custom-built breeds of live stock which were founded entirely or in a large part on strains of warm-country origin. The Los Baños Cantonese was built upon a race of chickens from Canton, China. The new strain proved so superior that it was soon accepted as the standard breed for the Philippines. Even Canton sent to Los Baños for this improved edition of the Cantonese chicken. The Berkjala swine, which combines the hardiness of the native Jalajala pig with the superior qualities of the Berkshire, has come to be a prized breed throughout the Archipelago. The Philamin cattle, into which are being fixed the desirable characteristics of the native cattle, the Hereford, and the Nellore, holds out much hope for the future of the Philippine cattle industry.

If Doctor Gonzalez had done nothing more than give the country these three improved breeds of live stock, he could have rested in his work, content in the assurance that he had accomplished the task of a lifetime. But, instead of the end, it proved to be only the beginning of a career of creation and organization. He kept on building up and reinforcing the equipment and personnel of his department to a point where it could render the most efficient service in research and instruction. With keen foresight, he handpicked his personnel. Perhaps subconsciously, in selecting his men he applied the same rigid rules of the animal breeder. He chose his faculty stock as carefully as if the fate of the whole institution depended on each man. He did not compromise with quality and he allowed no other consideration than merit to influence his judgment, even going to the extent of ruthlessly culling out those who in his opinion failed to come up to standard. His sponsorship of or, we might say, fanatical adherence to these principles made him many enemies who, although they did not always express active antagonism, held him in suspicious fear and accused him of vindictiveness. Hence, the root cause of most of the resistance that nearly cost him his appointment to the deanship of the College of Agriculture in 1927.

The opposition to his appointment as dean was probably a blessing in disguise. It wounded his pride and the challenge served to bring out the best in him, as did a similar untoward experience in his more tender years. The story is told that as a boy he was an accidental witness of a battle to death between two mother sows. The outcome of the fight was an orphaned litter of nine, which young Gonzalez took under his care. Despite his attention and trouble, the little pigs died one by one. When his protégés were nearly all gone, he desperately gave the unhappy survivors away to a farmer's wife, who somehow succeeded in rearing them, without a mishap, to maturity. The humiliating experience of an illiterate peasant woman besting him in such an apparently simple trick as rearing young pigs piqued him to the quick. He decided then and there to enter the College of Agriculture if for no other reason than to learn how to raise pigs. He took this step in defiance of established traditions in the Philippines, for Gonzalez was a rich man's son and up to then a rich man's son taking up dirt-farming had been an unheard-of phenomenon.

The record of Doctor Gonzalez as dean was one of unusual progress for the institution, not only in the way of buildings, equipment, and other physical improvements, but also in the type of instruction and instructors, student material, and research output. He bent all his efforts toward building up and maintaining a really first-class institution. His oft-repeated remark which he followed consistently to the letter was, "I want every product of this College, whether it be a student, a plant, a domestic animal, or a scientific paper, to bear a mark similar to that of 'sterling' on silver." The result was that the College won increased recognition not only in the Philippines but also in the rest of the world. The prestige of the College and its graduates became so enhanced that even rich men no longer hesitated to send their sons to Los Baños. The College of Agriculture, modesty aside, became the acknowledged leader in the scientific field in this country, as may be judged from the public utterances and reports of responsible Commonwealth officials, as well as from honorary positions accorded its dean and professors. Dean Gonzalez was elected a director of the Pampanga Sugar Development Company in 1927; he was the first president of the U. P. Chapter of the honor society of Phi Kappa Phi after its organization in 1933; president of the Philippine Society of Technical Agriculturists in 1934; fellow of the American Association for the Advancement of Science in 1934; president of the Society for the Advancement of Research in 1935-1936; a director of the National Development Company in 1934-1936; a member of the National Economic Council since 1938; vice-chairman of the National Research Council of the Philippines in 1934-1935; and chairman for the second term since 1938. Doctor Gonzalez's genius for organization had manifested itself even earlier when he founded in the College of Agriculture, long before he became the dean of the institution, much needed service entities such as the College Coöperative Company in 1916 and the Maquiling School for faculty children in 1924. He was also a cofounder of the Los Baños Biological Club in 1923, of which he was the first president from 1923 to 1925. Likewise, he was the secretary of the Seventh Philippine Agricultural Congress in 1926.

Doctor Gonzalez's accession to the presidency seems to have been foreordained by a tradition in his family when his late father, Dr. Joaquin Gonzalez, became president of the Universidad Literaria de Malolos which was established by the Aguinaldo Government. At forty-six years of age (he was born in Apalit, Pampanga, March 22, 1893), he is the youngest of all the incumbents of the chair in the University of the Philippines; but he is not so in administrative experience and maturity of judgment. In his own declaration before the Board of Regents, "in my own humble way, silently but unceasingly, for the last twenty years, I have been reading, studying, preparing for the position of president. Not that I knew I was going to be offered it, but because I felt it the duty of every faculty member to prepare himself for the time when the call for a higher service may be made". Despite his expressed desire first to be placed on probation as acting president, the Board of Regents under the chairmanship of His Excellency, President Manuel L. Quezon, of the Philippine Commonwealth, voted him permanent president. The man about whom doubts had been expressed as to his being good enough for the deanship of the College of Agriculture has amply vindicated himself; for he has proved that he is good enough to become the President of the University of the Philippines. That his appointment was acclaimed universally with satisfaction is indicated, ironically enough, by enthusiastic press comments in the same newspapers that had once been his most vicious assailants and by numerous letters and telegrams of congratulation.

L. B. UICHANCO
Dean, College of Agriculture

HEMATOLOGICAL STUDIES ON CATTLE: II. VARIATIONS IN HEMOGLOBIN IN INDIAN NELLORE OXEN AS AFFECTED BY ATMOSPHERIC TEMPERATURE, RELATIVE HUMIDITY, BODY TEMPERATURE, AND CERTAIN CHEMICAL COMPONENTS OF THE BLOOD[1]

By Miguel Manresa, Francisco Gomez and F. O. Santos

WITH ONE CHART

The failure of improved breeds of cattle of western origin to adapt themselves to the Philippine environment has not been satisfactorily traced to a definite cause. The usual explanations for this failure are the unfavorable climate, inadequate feed, and the prevalence of infectious and parasitic diseases. In a previous paper on the subject, Manresa and Reyes (1934) found definite differences in the hemoglobin content of the blood of differerent breeds of cattle raised in the College of Agriculture, University of the Philippines. Their results indicated that the hemoglobin index may be used as a guide in selection for adaptability to a given set of environmental conditions. The data which they reported included hemoglobin determinations for Indian Nellore cattle, Philippine native, Holstein, and Herefords. A more intensive work on the subject was, therefore, undertaken for the purpose of determining whether the hemoglobin is affected by the variations of such components of the blood as calcium, phosphorus, and sugar.

Review of literature

Studying the variations in the hemoglobin content of cattle at intervals of two and one-half hours in Florida, Neal and Becker (1933) claimed that the best time to get samples for uniformity was at 1:30 in the afternoon because samples taken at that hour were more uniform than at other hours. They also reported that samples taken at 8:30 a. m. were next in uniformity to those taken at 1:30 p. m.

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[1] The greater part of the data in this paper was in a thesis presented by Francisco Gomez in 1937 with the degree of Bachelor of Science in Agriculture from the College of Agriculture, No. 1060; Experiment Station contribution No. 1301. The thesis was prepared under the direction of Dr. Miguel Manresa of the Department of Animal Husbandry and of Dr. F. O. Santos of the Department of Agricultural Chemistry.

Burnett (1917) stated that "the blood may be considered as tissue composed of cellular and inter-cellular substances, the fluid portion being the inter-cellular substance". The remaining portion is considered by him as the cellular substance. He further stated that the blood is a peculiar tissue in that it is in intimate relation with practically all the other tissues of the body, bringing substances to them and carrying away other substances.

Claiming that additional data on chemical analysis of the blood of domesticated animals are necessary not only for the purpose of establishing the physiological normal composition of the blood, but also for the purpose of using the result of the examination as an aid to diagnosis, prognosis, and treatment, Hayden and Tubangui (1919) undertook the chemical analysis of the blood of various breeds of domesticated animals. The average sugar reading reported for cattle was 96.0 mg., and the range of variations was from 77 to 121 mg. per 100 cc. of blood.

From a total of sixty-eight chemical analyses of the blood of cows studied, Hayden and Fish (1928) reported that the lowest sugar reading was 30.0 mg. and the highest was 70.0 mg. The average of these analyses was 46.52 mg. per 100 cc. of blood. The average reported for calcium was 10.88 mg.; the minimum reading was 7.5 mg. and the maximum, 14.0 mg. per 100 cc. of blood. The inorganic phosphates in the cows averaged 5.7 mg., the minimum was 2.31, and the maximum was 9.63 mg. per 100 cc. of blood.

Objects of the work

More specifically the objects of the present experiment were:

(*a*) To determine the variations of hemoglobin readings at different hours of the day.

(*b*) To determine the best time or the best hour of the day to make these hemoglobin determinations.

(*c*) To find out what factors, if any, affect the hemoglobin readings.

(*d*) To determine by chemical analyses the amount of sugar, calcium, and phosphorus present in the blood at different hours of the day in Indian Nellore cattle raised in the College of Agriculture.

Time and place of the work

The experiment, started in May, 1934, and ended in August, 1936, covering a period of two years and three months.

The field and laboratory part of the work was done in the Department of Animal Husbandry. The chemical analyses of the blood were performed in the Department of Agricultural Chemistry, Los Baños, Laguna.

MATERIALS AND METHODS

As a preliminary part of the work, ten Indian Nellore cattle were used for this study. These animals were given the same feed throughout the whole period of experimentation and placed under similar conditions. The feed consisted of mixed grasses and silage. Water was available at all times. The blood samples were taken at intervals of two and one-half hours; at 6:30, 9:00, and 11.30 in the morning, and 2:00 and 4:30 in the afternoon.

The results of the foregoing experiment made it necessary to repeat the work so as to cover the entire day from midnight to noon and from noon to midnight; thus twenty-four hours of each day were covered. The intervals between sampling were made four hours instead of two and one-half hours; that is, samples were taken at 2:00, 6:00 and 10:00 a. m. and at 2:00, 6:00 and 10:00 p. m.

For this purpose only mature individuals consisting of six females and one male were used. This experiment was started on April 2, 1936, and was continued every day without interruption to April 8, 1936; thus a period of six days was covered.

Technique used for sampling of blood

(*a*) *Hemoglobin.* A small area on the ear (pinna) was cleaned and the hair cut short. After the usual antiseptic precautions were taken, the marginal ear vein was punctured with a lancet. The samples were collected after a few drops of the blood had fallen. The hemoglobin indices were determined by the new Newcomer improved method of hemoglobin determination. The samples were taken in triplicate, and the average of the three was the result reported for the determination.

(*b*) *Hemoglobin and relative humidity, atmospheric temperature, and body temperature.* Before taking the blood sample, the relative humidity and temperature of the air were determined with instruments at hand.[2] In taking the body temperature, the thermometer was held in the rectum for at least three minutes.

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[2] The humidometer and thermometer used were loaned to us by the Department of Agricultural Botany. These instruments were standardized by the Philippine Weather Bureau.

(*c*) *Sampling of blood for chemical analyses.* After the necessary precautions for antisepsis were taken, the jugular vein was punctured by a previously sterilized hypodermic needle of about 2 mm. in diameter and 53 mm. in length. Then the blood intended for sugar and phosphorus analysis was caught in a graduated flask containing 50 milligrams of dry potassium oxalate, until the 50 cubic-centimeter mark was reached.

Chemical analyses

To reduce errors due to slight variations in color readings in the determination of sugar and phosphorus components of the blood, seven readings were made of each sample throughout the experiment. Three samples for the determination of calcium were made for each animal.

A long series of experiments, covering a period of nearly three months, for the purpose of solving the difficulty encountered in freeing the blood from protein by the method of Folin and Wu (1919) were conducted. It appeared that the trouble arose from the use of a different kind of sodium tungstate. Hayden and Tubangui (1919), who encountered the same difficulty, were able to solve it only after they had used the sodium tungstate solution recommended by Folin and Wu (1919). In the present work a German sodium tungstate (Merck) was used as this was the only one available in the Agricultural Chemistry laboratory.

The modification which proved successful is here described. Instead of 20 mg. of potassium oxalate, in 10 ml. of blood, 10 mg. were used. This amount prevented coagulation of blood for as long as five days under refrigeration. Instead of 1 volume of 10 per cent sodium tungstate, 3 volumes of 20 per cent were added; and instead of 1 volume of 2/3 N of sulfuric acid, 2 volumes were used. Under such a method, the color of the coagulum changed from pink to dark-brown. The filtrate was water-clear, generally neutral, or very slightly acidic with congo red indicator. After such clarification, determination of sugar by the improved Folin and Wu (1919) method became routinary.

Some months later, when a new stock of sodium tungstate was received from the United States, tests were made to compare the results of the readings obtained from this method and that of Folin and Wu (1919). The results from the twelve tests made showed a close agreement.

The blood for calcium determination was collected in a 20 cc. test tube and placed in a refrigerator for two days, prior to analysis. The samples for sugar and phosphorus determination collected during the day time (6:00 and 10:00 a. m. and 2:00 p. m.) were taken to the laboratory and determinations were made without delay. Those taken at 2:00 a. m., and 6:00 and 10:00 p. m. were placed in the refrigerator at once. Determinations of these were made without delay the following day. No difficulty was encountered with the method of Kramer and Tisdall as modified by Clark and Collip (1925) for calcium determination. The inorganic phosphorus was determined by the Briggs modification of the Bell-Doisy method (1922).

DISCUSSION OF RESULTS

The hemoglobin readings at intervals of two and one-half hours

The results of the hemoglobin determination for young and mature Indian Nellore cattle are separately presented in tables 1 and 2. It may be noted in these tables that in both the young and mature animals, the general trend of the hemoglobin determination follows a regular curve: namely, higher in the morning and the late afternoon, and lower towards noon. For example, in table 1 (hemoglobin for young Indian Nellore cattle) the averages of hemoglobin were 9.41 gm. per 100 cc. of blood at 6:30 a. m.; 8.70 gm. at 9:00 o'clock a. m.; 8.53 gm. at 11:30 a. m.; 8.70 gm. at 2:00 o'clock p. m.; and 8.72 gm. at 4:30 p. m. The coefficient of variability of the determination at different hours shows that samples were least variable at 6:30 in the morning. The average of these determinations was 8.73 grams.

In table 2 (hemoglobin for mature Indian Nellore cattle) the averages of hemoglobin were 9.81 gm. per 100 cc. of blood at 6:30 a. m.; 9.19 gm., at 9:00 a. m.; 9.11 gm. at 11:30 a. m.; 8.92 gm. at 2:00 p. m.; and 9.27 gm. at 4:30 p. m. The coefficient of variability of the determination at different hours shows that samples were least variable at 4:30 p. m. The average for mature Nellore was 9.33 grams.

It is indeed very surprising that the greatest uniformity of the samples should occur at the extremes; thus, 6:30 a. m. with young animals and 4:30 p. m. with the mature ones.

The hemoglobin readings at intervals of four hours

These unexpected results made it necessary to repeat the experiment using only mature animals and taking the samples throughout the entire day at 2:00, 6:00, and 10:00 in the morning and at 2:00, 6:00, and 10:00 o'clock in the afternoon. This latter experiment covered a period of six consecutive days. The results are shown in table 3.

It is noted from this table that the trend of hemoglobin determinations was in agreement with that previously found for young and mature cattle: namely, higher in the morning and afternoon, and lower toward noon. But the hemoglobin readings continued to rise late in the afternoon and were still high at 10:00 o'clock in the evening and 2:00 o'clock the succeeding morning.

A statistical study of the data in table 3 shows that the least variable, therefore the most uniform samples of blood for hemoglobin, occurred at 10:00 o'clock in the evening with the mean, 10:45 ± 0.106 grams; standard deviation, 1.02 ± 0.075 grams; coefficient of variation, 9.77 ± 0.719 per cent. The lowest mean was 9.69 ± 0.112 grams; standard deviation, 1.07 ± 0.079 grams; coefficient of variation, 11.08 ± 0.768 per cent, registered at 2:00 o'clock in the afternoon.

It is not surprising, therefore, that the least variability in hemoglobin for mature animals should have occurred at 4:30 in the afternoon (table 2), although this was at one extreme, for at that time the coefficients of variability were still going down as shown in table 3. With regard to the hemoglobin of young animals, an entirely different condition may be established by future experimentation. If hemoglobin is affected by the nervous system, Mathews (1925), it is probable that great sensitiveness of young animals may account for this difference. Manresa and Reyes (1934) stated that the condition of the animal affected adversely the hemoglobin content of the blood. The data here reported confirm their results. For, after a continuous strain of only seven days, the hemoglobin of the blood of the animals studied was significantly reduced from 11.19 ± 0.182 to 9.50 ± 0.098; the difference was 1.69 ± 0.206 or more than eight times its probable error.

Correlations between hemoglobin and relative humidity, atmospheric temperature, and body temperature

In order to determine the influence of relative humidity and atmospheric temperature upon the hemoglobin, the following correlations were made: (a) between hemoglobin and relative humidity, (b) between atmospheric temperature and hemoglobin, (c) between body temperature and atmospheric temperature. The correlation coefficients show that hemoglobin is not affected by humidity. It was found, however, that the atmospheric temperature and hemoglobin exhibited a slight negative correlation; the correlation coefficient was — 0.226 ± 0.0403. This correlation coefficient is low, but it tends to show that as atmospheric temperature rises, within the limits of the present observation, the hemoglobin falls. We have also found that the body temperature is positively correlated with atmospheric temperature, the correlation coefficient being + 0.476 ± 0.0328 (table 4). This correlation is moderately high and significant.

In view of these results, it is not likely that a particular time of the day will be found in which samples of blood will give uniform results for hemoglobin because atmospheric temperature is not constant at any given hour of the day. These results are at variance with those reported by Neal and Becker (1933) who claimed that the best time to get blood samples is 1:30 p. m. and the next most satisfactory time is 8:30 a. m. This experiment was done in Florida, United States of America, and it may be that localities differ in this respect.

From these observations, it is not unlikely that high temperature has a detrimental effect upon the improved breeds of cattle of western origin brought to the tropics. In their own country, the improved breeds show high hemoglobin content. Brooks and Hughes (1932) reported that the hemoglobin in the blood of the Jersey was 11.60 ± 0.203 grams; of the Guernsey, 10.34 ± 0.125 grams; of the Ayrshire, 11.44 ± 0.175 grams; and of the Holstein-Friesian, 11.10 ± 0.081 grams. While in this country, Manresa and Reyes (1934) reported 9.87 ± 0.09 grams for the Indian Nellore, 9.46 ± 0.13 grams for the Philippine native, 8.28 ± 0.17 grams for the Holstein-Friesian, and 6.76 ± 0.11 grams for the Hereford. Comparing the Holstein's hemoglobin in its own country to that here reported, a difference of 2.82 ± 0.188 grams was found. This difference is fifteen times its probable error and shows that in the Philippines the hemoglobin of Holstein cattle is significantly low. According to Mathews (1925), the central nervous system is more dependent on oxygen than any other tissues of the body. Since oxygen must be carried by hemoglobin, it is obvious that lack of it reduces the metabolic processes. Notwithstanding the fact that the Indian Nellore cattle are already acclimated in the Philippines, it was found that even they suffer slight reduction in hemoglobin when the temperature is high. With animals that are still undergoing acclimatization, the effect of temperature would be more severe. This is borne out by the observation of Rhoad (1936) who found that the extreme environmental temperature in Brazil exerted a marked influence on the metabolism of imported European cattle.

Gonzalez (1926) believes that the abundance of moisture in an environment of high temperature is very favorable to the rapid multiplication of parasites. Doubtless other factors, as yet unknown, are at work. More experimentation on other subjects is necessary so as to solve once and for all the question of importing occidental breeds of cattle for acclimatization into tropical countries.

Chemical analyses of blood

In view of the fact that we were unable to determine the best time to obtain samples for making chemical analyses of the blood for calcium, phosphorus, and sugar, the samples were taken throughout the entire day at intervals of four hours: namely, at 2:00, 6:00, and 10:00 o'clock a. m., and at 2:00, 6:00, and 10:00 o'clock p. m. Table 5 shows the variation in hemoglobin indices obtained from this study. The data therein again show that the hemoglobin is higher early in the morning and late in the afternoon, but lower towards noon. The coefficients of variability show that the least variable samples were obtained at 6:00 o'clock in the morning. This time did not exactly coincide with the results previously reported for mature animals, owing undoubtedly to variations in such environmental factors as relative humidity and temperature of the air. It must be mentioned, however, that on the whole the variations in hemoglobin readings were greatest during the hotter time of the day at noon hours, and least during the cooler part of the day, that is, from 2 to 10 o'clock in the morning.

Table 6 shows the variations in calcium from samples taken at different hours of the day. The outstanding feature of these data is the great uniformity of calcium in the blood of different animals as shown by the coefficients of variation. Animal number 41 gave 12.13 mg. of calcium per 100 cc. of blood in every test-hour throughout the entire period of the test. Hence, the coefficient of variation was zero. The other animals showed so little variation that the highest coefficient of variability was 2.61 per cent as may be seen in the table. The minimum determination for the group was 11.16 mg. and the maximum was 14.28 mg. given by animal No. 46, a male. The average of calcium for the whole group was 12.35 mg. per 100 ml. of blood. From the different hours the coefficients of variability ranged from 7.45 per cent to 8.44 per cent; thus the calcium in the blood of Indian Nellore was found to be very constant. This is graphically shown in chart 1. Comparing these data with those reported by Hayden and Fish (1928) for cows (breeds not given), namely, average 10.88 mg., range 7.5 to 14.0 mg., we find that the Indian Nellore have a higher calcium content in their blood than those reported by Hayden and Fish.

Table 7 shows the variations in phosphorus at different hours of the day. The coefficients of variability for the different individuals in the group during the entire period of the test ranged from 10.11 per cent to 28.90 per cent. The minimum phosphorus content was given by animal No. 54, which was 2.10 mg. The maximum reading was obtained from animal No. 46 which was 4.39 mg. The average for the group was 2.95 mg., standard deviation 0.258 mg. and coefficient of variability 8.74 per cent, per 100 ml. of blood. The coefficient of variation of the group at different hours of the day ranged from 7.89 to 21.34 per cent; thus phosphorus is shown to be subject to great fluctuation. Chart 1 shows graphically the phosphorus content in the blood for the group of Indian Nellore cattle studied.

The inorganic phosphate reported by Hayden and Fish on cows (breeds not given) was 5.7 mg. the range of readings being from 2.31 to 9.63 mg. per 100 cc. of blood. From this report it would appear that the Indian Nellore cattle used in this study have lower phosphorus in their blood than those reported by Hayden and Fish (1928).

Of the three chemical constituents of the blood analyzed, sugar was found to be the most variable as may be seen in table 8. One animal, No. 54, gave a coefficient of variation of 28.91 per cent. The least variation in sugar was given by animal No. 41, namely, 2.84 per cent. It appears that the majority of the animals show great variation in the sugar content of their blood. The variation at different hours of the day for the group ranges from 10.45 per cent to 25.80 per cent. On the whole sugar in the blood is high at 6:00 and 10:00 in the morning, and at 6:00 in the afternoon; and low at 2:00 in the afternoon, at 10:00 in the evening, and at 2:00 in the morning. This is graphically shown in chart 1. The average sugar content for the group was 69.42 mg., standard deviation 10.82

mg., and coefficient of variability 15.59 per cent. The range was 44.44 mg. to 116.27 mg. per 100 cc. of blood.

Analyzing for sugar in cows (breeds not given) Hayden and Tubangui (1919) reported the average to be 96 mg. per 100 cc. of blood with a range of variation from 77 to 121 mg. The data for cattle for the same subject as reported by Hayden and Fish (1928) showed an average of 46.52 mg. The range was from 30 to 70 mg. per 100 cc. of blood. This lack of agreement in the data shows that sugar is very variable. On the basis of these results, it is very difficult to establish the norm of sugar for any individual with a single determination. In analyzing our results we applied Wright's (1925) statistical method of determining the minimum number of samples that will be needed to establish a normal sugar content. The varia-

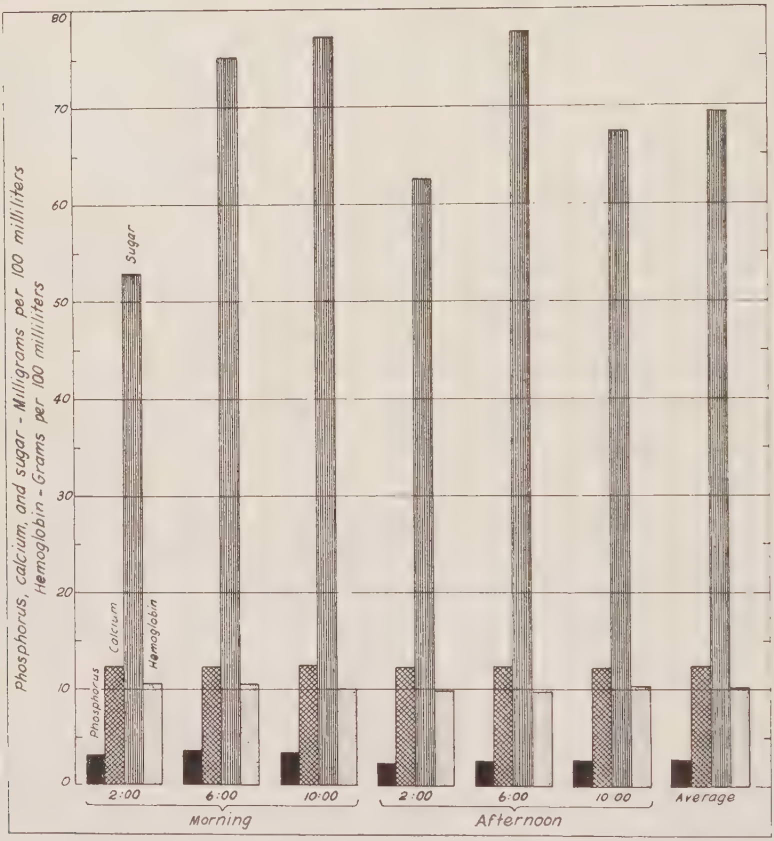

Chart I.—Showing the fluctuations of four chemical components of the blood of Indian Nellore oxen in the course of 24 hours.

tions were so great that a minimum of 40 samples was needed before such a norm could be established.

Inspection of the data shown in chart 1 discloses the fact that no consistent relationship exists between hemoglobin and calcium nor between sugar and phosphorus. The calcium remained constant throughout the entire period. Sugar was the most variable and did not seem to follow the fluctuation of any chemical component of the blood studied. Phosphorus was low at 2:00 a. m., rose slightly at 6:00 and 10:00 a. m., was low again at 2:00 p. m. and rose at 6:00 and 10:00 p. m. Since hemoglobin and phosphorus seemed to have some agreement, a correlation of these was made. The coefficient of correlation was found to be 0.264 ± 0.096, which is not significant.

SUMMARY AND CONCLUSION

1. Hemoglobin determinations at two and one-half hour intervals in both young and mature Indian Nellore cattle were higher early in the morning and late in the afternoon and lower toward noon. In young animals the most uniform samples were at 6:30 in the morning; and in the adult, at 4:30 in the afternoon.

2. In samples for hemoglobin determination taken at intervals of four hours throughout the entire day, the most uniform reading was obtained at 10:00 in the evening. Because the hemoglobin reading was correlated negatively with atmospheric temperature (0.226 ± 0.040) to a slight extent, it is not likely that a specific time of the day can be found in which samples of blood will give regularly uniform results. This is because the atmospheric temperature is not constant at any given hour of the day.

3. Body temperature and atmospheric temperature were positively correlated. The correlation coefficient was 0.476 ± 0.0328. This correlation was moderately high and significant.

4. The serum calcium in the blood of Indian Nellore cattle taken at intervals of four hours throughout the entire day exhibited great uniformity. The average from seven animals studied was 12.35 mg. per 100 ml. of blood.

5. The inorganic phosphorus similarly analyzed showed great variability. The range of readings for phosphorus was from 2.10 to 4.39 mg. The average for the group was 2.95 mg.; standard deviation, 0.258 mg., and coefficient of variation, 8.74 per 100 ml. of blood.

6. Of the three chemical constituents analyzed, sugar was found to be the most variable. The range of variation in the course of

twenty-four hours from samples taken at intervals of four hours was 44.44 mg. to 116.27 mg. per 100 ml. of blood. The average for the day was 69.42 mg.; standard deviation, 10.85 mg.; and coefficient of variation, 15.59 per cent. These data emphasize the need of taking several samples at different times of the day when analyzing for sugar content of blood before a norm can be established. This statement holds true also for phosphorus. For hemoglobin determination, three samples taken in the morning, noon, and in the afternoon would ordinarily give the average reading for the day. With calcium, one sample is sufficient.

7. Quantitatively, none of the three chemical components of the blood analyzed was found to have any relation with the fluctuations of hemoglobin. The adverse effect of temperature on hemoglobin is definitely shown.

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TABLE 1

Variations in hemoglobin from samples taken at intervals of two and one-half hours: 6:30, 9:00, 11:30 a. m., 2:00, and 4:30 p. m. from young Indian Nellore oxen (1-3 years), in grams per 100 ml. of blood

DATE	ANIMAL NO.	A. M.			P. M.		AVERAGE
		6:30	9:00	11:30	2:00	4:30	
1935		gm.	gm.	gm.	gm.	gm.	gm.
May 9	65	10.59	9.20	9.15	9.28	8.86	9.45
	68	9.33	8.39	8.85	8.81	9.34	8.95
	66	9.70	9.88	9.25	9.43	9.63	9.57
	64	9.80	8.93	8.47	8.55	8.55	8.83
May 10	62	9.04	8.67	8.43	9.11	8.51	8.57
May 17	65	8.62	7.40	6.97	6.78	6.90	7.30
	68	8.44	7.50	6.64	7.25	7.70	7.41
May 18	62	10.11	9.18	9.32	9.62	9.65	9.58
	64	8.64	8.26	8.63	8.77	8.99	8.66
	66	9.89	9.68	9.59	9.53	9.65	8.73
Average		9.41	8.70	8.53	8.70	8.72	8.73
Standard deviation		0.71	0.75	1.80	0.98	0.94	0.70
Coefficient of variability		7.52	8.60	11.76	11.26	10.96	8.13

TABLE 2

Variations in hemoglobin from samples taken at intervals of two and one-half hours: 6:30, 9:00, 11:30 a. m., 2:00, and 4:30 p. m. from mature Indian Nellore oxen (6-10 years), in grams per 100 ml. of blood

DATE	ANIMAL NO.	A. M.			P. M.		AVERAGE
		6:30	9:00	11:30	2:00	4:30	
1935		gm.	gm.	gm.	gm.	gm.	gm.
May 7	41	10.60	7.47	6.38	7.67	8.47	8.59
	42	10.70	8.60	7.58	8.73	9.70	9.06
May 8	49	10.87	11.67	11.26	10.54	10.77	11.07
	52	11.58	10.39	11.55	10.38	10.61	10.90
	54	9.61	9.39	9.59	8.97	8.83	9.48
May 15	41	9.34	8.21	7.83	7.81	8.77	8.43
	42	9.24	9.12	8.82	7.96	8.86	8.80
May 16	49	10.10	10.04	9.94	10.12	10.11	10.08
	52	8.43	8.46	8.97	9.55	8.33	8.75
	54	7.69	8.62	8.75	7.49	8.26	8.16
Average		9.81	9.19	9.11	8.92	9.27	9.33
Standard deviation		1.10	1.16	1.24	1.26	0.90	1.04
Coefficient of variability		11.22	12.47	14.26	14.32	9.79	10.10

TABLE 3

Variations of hemoglobin from samples taken at intervals of four hours: 2:00, 6:00, and 10:00 o'clock a. m.; and 2:00, 6:00, and 10:00 o'clock p. m., from mature animals (6-10 years) in grams per 100 ml. of blood

TIME	ANIMAL NO.	DATE: APRIL 3 TO 8, 1936, INCLUSIVE						AVERAGE	MEAN
		3	4	5	6	7	8		
A. M.									*grams*
2:00	35	15.3	9.4	11.8	9.3	9.3	9.7	10.77	11.12 ± 0.193
	41	12.6	8.5	10.2	10.0	9.1	8.5	9.81	
	42	15.5	9.7	11.4	12.5	11.1	9.7	11.63	
	49	15.4	10.7	12.5	11.9	12.2	10.3	11.86	
	52	14.1	9.9	10.7	11.8	11.6	9.9	11.32	
	54	13.3	9.2	10.5	11.7	11.4	9.1	10.88	
	46	12.7	8.9	10.4	11.2	10.2	9.2	10.43	
6:00	35	12.1	8.1	9.5	10.3	9.5	10.00	9.91	10.17 ± 0.137
	41	11.3	8.0	9.7	10.2	9.5	8.0	9.44	
	42	12.7	8.4	11.0	11.7	10.4	10.1	10.71	
	49	13.2	9.8	11.7	11.6	11.7	10.2	11.36	
	52	11.9	9.6	11.5	10.8	11.0	9.6	10.72	
	54	10.9	8.0	10.8	9.8	10.5	9.2	9.91	
	46	12.0	9.1	8.9	9.4	10.1	9.2	9.78	
10:00	35	11.1	8.8	9.1	8.8	9.8	9.6	9.53	10.02 ± 0.122
	41	9.7	8.8	9.3	8.9	8.7	7.7	8.84	
	42	11.8	10.1	10.8	10.5	11.3	9.7	10.69	
	49	12.7	10.9	11.9	11.5	11.5	10.1	11.42	
	52	12.0	10.9	11.0	10.4	11.5	9.9	10.94	
	54	10.4	9.4	9.5	8.9	11.2	9.1	9.73	
	46	10.6	9.0	9.1	8.8	10.2	8.6	9.38	

TABLE 3 Continued

TIME	ANIMAL NO.	DATE: APRIL 3 TO 8, 1936, INCLUSIVE						AVERAGE	MEAN
		3	4	5	6	7	8		
P. M.									*grams*
2:00	35	9.8	8.2	8.9	8.6	10.6	9.2	9.22	9.69 ± 0.112
	41	9.5	8.7	8.2	8.4	9.1	7.5	8.56	
	42	10.5	9.8	10.4	10.2	11.4	9.7	10.32	
	49	11.9	10.5	10.7	11.3	11.5	10.1	11.99	
	52	10.1	9.9	11.5	10.7	11.1	9.7	10.49	
	54	9.7	8.6	9.2	9.6	10.1	8.9	9.33	
	46	9.8	8.6	8.8	8.9	10.1	8.4	9.07	
6:00	35	9.8	9.9	9.5	11.3	9.6	9.3	9.78	10.40 ± 0.118
	41	9.2	9.4	9.6	10.7	8.6	8.0	9.24	
	42	10.3	9.7	10.3	11.7	10.2	10.2	10.40	
	49	11.8	11.4	11.5	13.6	11.6	11.2	11.76	
	52	10.4	13.2	10.8	12.0	10.7	10.0	11.16	
	54	9.9	11.1	10.1	12.2	9.9	10.1	10.56	
	46	9.7	10.4	10.9	11.0	9.5	9.8	10.14	
10:00	35	10.0	10.0	10.5	10.2	9.1	9.3	9.85	10.45 ± 0.106
	41	8.6	9.9	10.7	9.8	8.6	8.3	9.31	
	42	10.7	11.1	11.9	11.5	10.6	10.8	11.09	
	49	10.5	12.2	13.2	11.7	11.3	11.6	11.75	
	52	10.8	10.9	12.8	11.6	9.7	10.2	11.00	
	54	9.8	10.2	12.7	10.7	9.5	9.6	10.41	
	46	10.9	10.5	11.1	9.4	9.6	9.2	10.12	
Weighted mean P. E.		11.19 ± 0.182	9.66 ± 0.158	10.47 ± 0.119	10.52 ± 0.103	10.38 ± 0.105	9.50 ± 0.098		10.26 ± 0.087

TABLE 4

Correlation between atmospheric temperature and body temperature of the Indian Nellore breed of cattle

RANGES	VALUES	37.78	37.94	38.11	38.27	38.44	38.60	38.77	38.94	39.11	39.27	39.44		f	d	fd	fd^2	P
		37.83	38.00	38.15	38.33	38.49	38.66	38.83	39.00	39.15	39.33	39.49						
22.7-23.33	23.0	—	2	1	3	1	—	—	—	—	—	—	—	7	—6	— 42	252	+108
23.4-24.0	23.7	—	2	1	3	8	7	3	—	—	—	—	—	24	—5	—120	600	+110
24.1-24.7	24.4	—	2	1	9	9	2	3	—	1	—	—	—	27	—4	—108	432	+124
24.8-25.4	25.1	—	—	3	5	2	4	2	1	—	—	—	—	17	—3	— 51	153	+ 51
25.5-26.1	25.8	—	—	—	6	7	9	3	1	—	—	—	—	26	—2	— 52	104	+ 20
26.2-26.8	26.5	—	1	4	5	8	5	11	1	1	—	—	—	36	—1	— 36	36	+ 28
26.9-27.5	27.2	—	—	—	5	7	1	2	1	—	—	—	—	16	0	—	—	—
27.6-28.2	27.9	—	—	1	3	8	11	10	4	4	—	—	—	41	1	41	41	+ 13
28.3-28.9	28.6	—	—	—	—	1	—	5	1	—	—	—	—	7	2	14	28	+ 12
29.0-29.6	29.3	—	—	—	—	1	—	—	—	—	—	—	—	1	3	3	9	+ 3
29.7-30.3	30.0	—	—	—	—	1	2	4	2	—	—	—	—	9	4	36	144	+128
30.4-31.0	30.7	—	—	—	1	4	3	10	3	3	—	2	—	25	5	125	625	+130
31.1-31.7	31.4	—	—	—	1	1	—	2	1	—	—	—	—	5	6	30	180	+ 7
31.8-32.4	32.1	—	—	—	—	—	1	4	—	—	—	—	—	5	7	35	245	+ 28
32.5-33.1	32.8	—	—	—	—	—	—	1	—	—	—	—	—	1	8	8	64	+ 8
33.2-33.8	33.0	—	—	—	—	—	1	3	—	—	—	—	—	5	9	45	405	+ 54
		f'	7	11	41	58	46	63	15	9	0	2	—	252	—	—72	3318	726
		d	— 4	— 3	— 2	— 1	0	1	2	3	4	5	—					
		fd	—28	—33	—82	—58	—	63	30	27	—	10	—					
		fd^2	112	99	164	58	—	63	60	81	0	50	—					

$$Rxy = 0.476 \pm 0.0328$$

TABLE 5

Variations in hemoglobin from samples taken at 2:00, 6:00, and 10:00 a. m., and 2:00, 6:00, and 10:00 p. m., in milligrams per 100 cc. of blood

ANIMAL NUMBER	A. M.			P. M.			MEANS FOR DIFFERENT INDIVIDUALS		
	2:00	6:00	10:00	2:00	6:00	10:00	Mean	Standard deviation	Coefficient of variability
	mgm.	*mgm.*	*mgm.*	*mgm.*	*mgm.*	*mgm.*	*mgm.*	*mgm.*	*per cent*
35	11.1	11.0	10.4	9.6	10.7	11.1	10.7	0.77	7.28
41	10.1	10.0	9.5	8.7	9.7	10.9	9.8	0.77	8.03
42	9.9	10.2	9.4	9.2	8.2	8.8	9.3	0.77	8.32
49	11.6	11.2	11.8	11.3	11.5	11.7	11.5	0.00	0.00
52	10.5	10.6	10.8	11.1	10.6	10.8	10.7	0.37	3.50
54	10.4	10.2	9.2	9.9	9.2	9.2	9.7	0.42	5.68
46	10.5	10.2	9.3	8.8	8.9	9.6	9.6	0.26	2.73
Means for group	10.6	10.6	10.0	9.9	9.8	10.3	10.17		
Standard deviation ...	0.78	0.42	0.73	1.77	1.02	1.32	0.73		
Coefficient of variability	7.29	4.01	7.32	12.13	10.45	12.94	7.32		

TABLE 6

Variations in calcium from samples taken at 2:00, 6:00, and 10:00 a. m., and 2:00, 6:00, and 10:00 p. m., in milligrams per 100 cc. of blood

ANIMAL NUMBER	A. M.			P. M.			MEANS FOR DIFFERENT INDIVIDUALS		
	2:00	6:00	10:00	2:00	6:00	10:00	Mean	Standard deviation	Coefficient of variability
	mgm.	*mgm.*	*mgm.*	*mgm.*	*mgm.*	*mgm.*	*mgm.*	*mgm.*	*per cent*
35	12.59	12.59	12.36	12.36	12.36	12.36	12.44	0.08	0.68
41	12.13	12.13	12.13	12.13	12.13	12.13	12.13	0.00	0.00
42	11.65	11.46	12.01	11.74	11.47	11.68	11.63	0.18	1.56
49	12.26	12.11	12.24	12.48	12.36	12.16	12.27	0.04	0.03
52	10.73	11.29	11.65	11.14	11.19	10.94	11.16	0.29	2.61
54	12.47	12.47	12.11	12.11	12.36	12.49	12.34	0.15	1.22
46	14.40	14.13	14.22	14.12	14.40	14.44	14.28	0.14	0.96
Means for group	12.32	12.31	12.39	12.29	12.32	12.31	12.35		
Standard deviation ...	1.22	0.92	1.06	0.92	0.96	1.02	0.92		
Coefficient of variability	8.44	7.45	8.04	7.45	7.45	8.44	7.45		

TABLE 7

Variations in phosphorus from samples taken at 2:00, 6:00, and 10:00 a. m., and 2:00, 6:00, and 10:00 p. m., in milligrams per 100 cc. of blood

ANIMAL NUMBER	A. M.			P. M.			MEANS FOR DIFFERENT INDIVIDUALS		
	2:00	6:00	10:00	2:00	6:00	10:00	Mean	Standard deviation	Coefficient of variability
	mgm.	*mgm.*	*mgm.*	*mgm.*	*mgm.*	*mgm.*	*mgm.*	*mgm.*	*per cent*
35	2.85	2.44	2.89	2.17	2.54	2.54	2.57	0.28	11.18
41	3.26	2.58	3.10	2.48	2.83	2.83	2.84	0.28	10.11
42	2.95	3.50	3.47	2.61	2.83	2.29	2.93	0.42	14.54
49	3.27	4.32	3.95	2.17	2.61	3.33	3.28	0.77	23.54
52	3.46	4.21	3.81	2.38	2.94	2.27	3.34	0.74	23.23
54	3.14	3.44	3.20	2.16	2.39	2.10	2.79	0.55	20.21
46	2.23	4.39	3.77	2.17	2.46	2.43	2.91	0.83	28.90
Means for group	3.02	3.56	3.46	2.31	2.66	2.68	2.95		
Standard deviation ...	0.36	0.75	0.37	0.35	0.21	0.40	0.26		
Coefficient of variability	12.18	21.34	10.86	18.03	7.89	15.95	8.74		

TABLE 8

Variations in sugar from samples taken at 2:00, 6:00, and 10:00 a. m., and 2:00, 6:00, and 10:00 p. m., in milligrams per 100 cc. of blood

ANIMAL NUMBER	A. M.			P. M.			MEANS FOR DIFFERENT INDIVIDUALS		
	2:00	6:00	10:00	2:00	6:00	10:00	Mean	Standard deviation	Coefficient of variability
	mgm.	*mgm.*	*mgm.*	*mgm.*	*mgm.*	*mgm.*	*mgm.*	*mgm.*	*per cent*
35	46.29	57.31	56.40	57.56	49.14	61.34	54.66	5.22	9.55
41	44.44	55.24	55.86	52.35	46.83	60.33	52.50	2.01	2.84
42	74.07	72.72	82.98	60.42	91.32	63.89	74.22	10.57	14.28
49	59.52	79.68	80.64	63.49	88.10	68.02	73.24	12.24	16.72
52	53.19	79.05	87.33	67.56	90.91	72.99	75.17	12.63	16.80
54	44.44	116.27	101.52	81.96	101.63	64.10	84.98	24.56	28.91
46	70.17	69.93	75.75	54.20	75.47	81.30	71.14	8.49	11.94
Means for group	52.97	75.03	77.21	62.51	77.63	67.42	69.42		
Standard deviation ...	11.39	18.79	15.25	9.31	20.03	6.91	10.82		
Coefficient of variability	20.34	24.81	19.75	14.90	25.80	10.25	15.59		

FIFTY THOUSAND KILOMETERS ON ALCOHOL AS MOTOR FUEL[1]

A. L. TEODORO
Of the Department of Agricultural Engineering

WITH FOUR TEXT FIGURES AND ONE CHART

A report is made in the present paper of experiences in driving a private car for a period of five years using alcohol as motor fuel. The engine behavior as regards starting, acceleration, power, engine wear, corrosion, and mileage under different driving conditions was noted. The car used was a De Soto De Luxe Sedan, 1929 model, which has the following specifications:

SPECIFICATIONS[2]

Engine

L-type, water-cooled, six cylinders, four-cycle. Bore 3″, stroke 4⅛″, N.A.C.C. horsepower 21.6, developed horsepower 55, piston displacement 174.9 cubic inches. Suspension: rear, arms, integral with clutch housing and bolted to steel brackets on frame side members; front, bolted to frame cross member. Insulated with rubber front and rear. Unit type. Firing order 1-5-3-6-2-4. Full force feed lubrication to all crankshaft, camshaft, and connecting rod bearings. Spray from metered hole in connecting rod bearings lubricates cylinders. Four-bearing crankshaft. Four-bearing camshaft. (Fig. 1).

Cylinders

Six, cast en bloc, integral with crankcase, with heavy cross web construction of main bearing supports. Detachable cylinder head. Bore 3″, stroke 4⅛″. Finish, reamed and honed. Oil passages are drilled through bosses integral with crankcase casting. (Fig. 2).

Pistons

Light alloy, ventilated bridge type. Length 3-11/16″. Fitting clearance .002″.

Piston Rings

Gray, iron, 3 per piston, concentric, 2 upper compression rings, special tongue and groove design 11/64″ wide. Special oil-control ring in lower groove ⅛″ wide.

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[1] Experiment Station contribution No. 1302.

[2] De Soto Six Instruction Book. Fifth Edition, October, 1929. pp. 78-80. De Soto Motor Corporation, Detroit, Michigan.

Valves

Inlet, flat head chrome-nickel steel. Exhaust, silcrome steel. Location: Right side, enclosed. Clear diameter of opening 1-5/16″, stem 11/32″, 45-degree seat. Lift 5/16″. Valve stem guides removable.

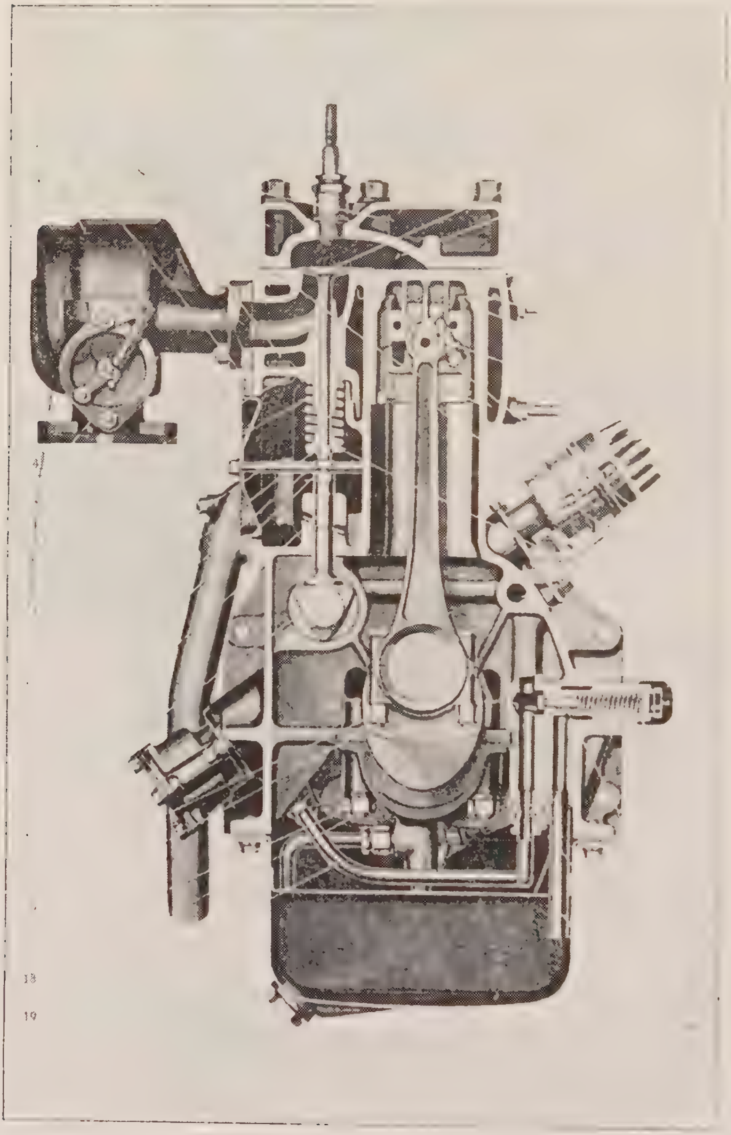

Fig. 1.—Front sectional view of engine. From De Soto Six Instruction Book, 5th edition, October, 1929.

Valve Tappets

Mushroom type. Chilled cast iron head welded to hollow steel stem. Mounted in cylinder block. Tappet clearance: Exhaust .007, intake .005.

Carburetor

Plain-tube type, provided with idle-speed adjustment and fixed jets, covering all necessary ranges to compensate for variations of altitude, peak summer and winter conditions. Equipped with air cleaner.

Electrical System

Generator—Third brush regulation, six-volt type. Starting Motor—Six-volt type with Manual shift. Battery—Six-volt, 90-ampere-hour capacity. Single wire system. Ignition—Top outlet waterproof distributor and coil. Semi-automatic advance. Six-volt battery ignition. North East Service, Inc., Rochester, N. Y.

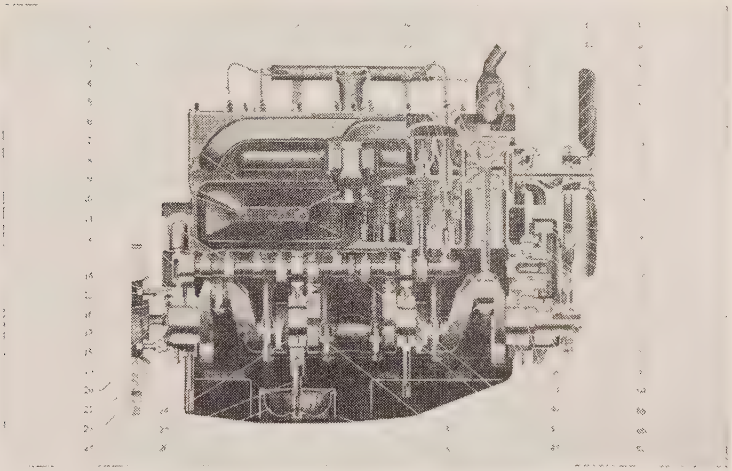

Fig. 2.—Side sectional view of engine. From De Soto Six Instruction Book, 5th edition, October, 1929.

Fuel System

Vacuum tank supply system, eleven-gallon fuel tank mounted at rear of frame. Fuel supply of tank of rust-proof, Terne plate.

Cooling System

Water (capacity 2½ gallons), circulated by centrifugal pump driven by extension of fan shaft Extra large water passages completely surround each cylinder and each valve. Cellular radiator with detachable shell. Four-blade 14-3/4" fan driven by V-belt with adjustment provided.

Tires

Balloon cords. non-skid tread on all wheels, size 5.00/19.

Transmission

Three-speed, selective sliding gear type. Unit with engine. Main shaft mounted on ball bearings with bronze pilot bearings. Countershaft bronze bearings. All gears are chrome steel.

GEAR RATIO	PROPELLER SHAFT	FINAL DRIVE
High	1 to 1	4.7 to 1
Intermediate	1.82 to 1	8.55 to 1
Low	3.04 to 1	14.28 to 1
Reverse	3.65 to 1	16.85 to 1

Lubrication—Engine

High pressure to all crankshaft, connecting rod and camshaft bearings. Pump located on right side of crankcase, driven by timing shaft from spiral gear on camshaft. All other working parts lubricated by positive spray under pressure from metered hole in upper half of each connecting rod bearing, also from crankshaft and camshaft. Timing chain lubricated by direct oil leads. Oil-filtered, cleansed and cooled by circulation through oil filter mounted on dash. Oil capacity 1½ gallons. Pressure gauge on instrument panel. Level indicator on left side of crankcase toward the rear from the filler.

Weight

The car is a De Luxe Sedan type with car serial No. KD883Y and engine serial No. K110,505. The weight without tools and fuel is 1,206 kilos and with the tools and fuel, 1,395 kilos.

Inlet valve opens at 6° after H.E.D.C. and closes at 46° after C.E.D.C. The duration of inlet valve opening is 220°. The exhaust valve opens at 42° before C.E.D.C. and closes at 8° after H.E.D.C. The duration of exhaust valve opening is 230°. The tappet clearances are 0.005 for inlet and 0.007 for exhaust, adjusted hot.

The ignition timing for gasoline at advanced spark lever position is 0.035″ before H.E.D.C.

The maximum brake horsepower that the engine can develop at 3400 r.p.m. is 57. The rated standard compression ratio is 5.2.

EXPERIMENTAL

The car was bought in May, 1930. Gasoline was used as fuel from the time it was purchased till January, 1934. The total distance covered during this time was 10,678.3 miles. The fuel economy was not recorded during this period.

The car was used for experimental purposes beginning February, 1934. Before alcohol fuels were used the cylinder head was removed and the carbon deposits were scraped off. The crankcase was thoroughly cleaned, the valves ground, the cylinders polished, and a new oil filter installed. A new set of spark plugs was used. The diam-

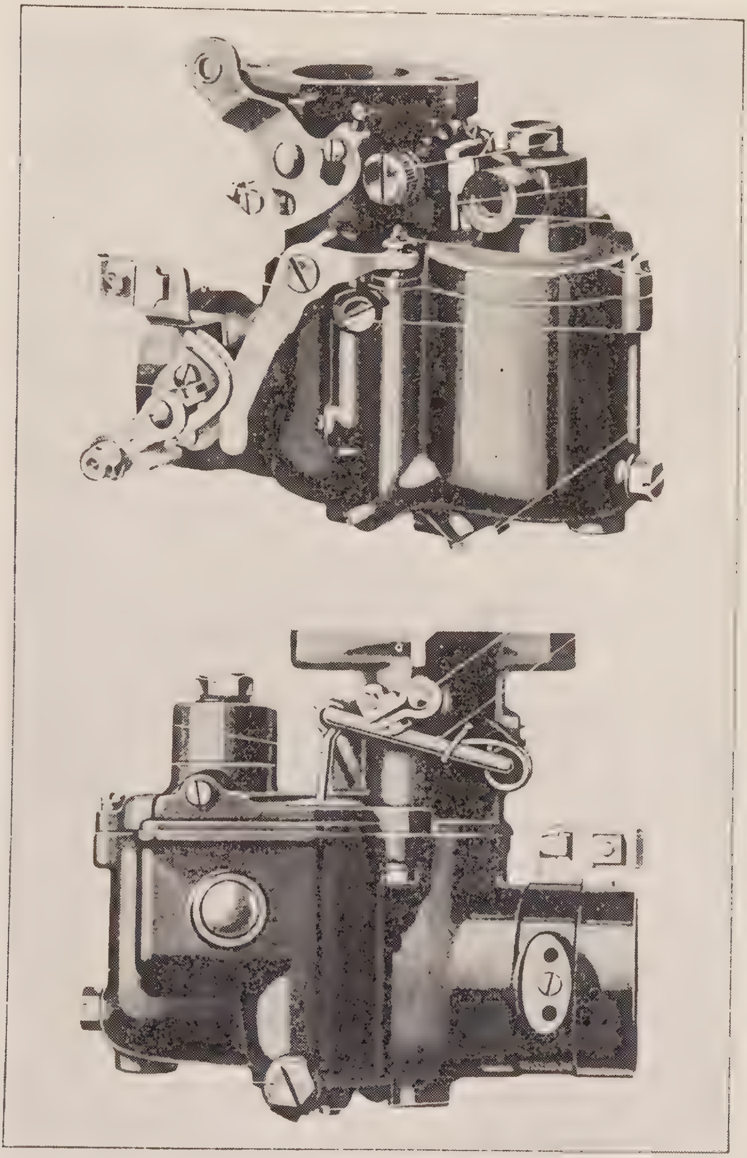

Fig. 3.—Carburetor. Plain tube type. Stromberg. From De Soto Six Instruction Book, 5th edition, October, 1929.

eter of the high speed metering jet was enlarged to make the area 1½ times as large as the original. The amount of fuel admitted was regulated by an adjustable needle. (fig. 3). The area of the pump discharge jet was increased a little. Ignition timing was set 5 to 14 degrees ahead of the usual adjustment for gasoline. Idling adjustment was changed according to the kind of alcohol motor fuel used. No alteration was made on the size of the choke opening. (Fig. 4).

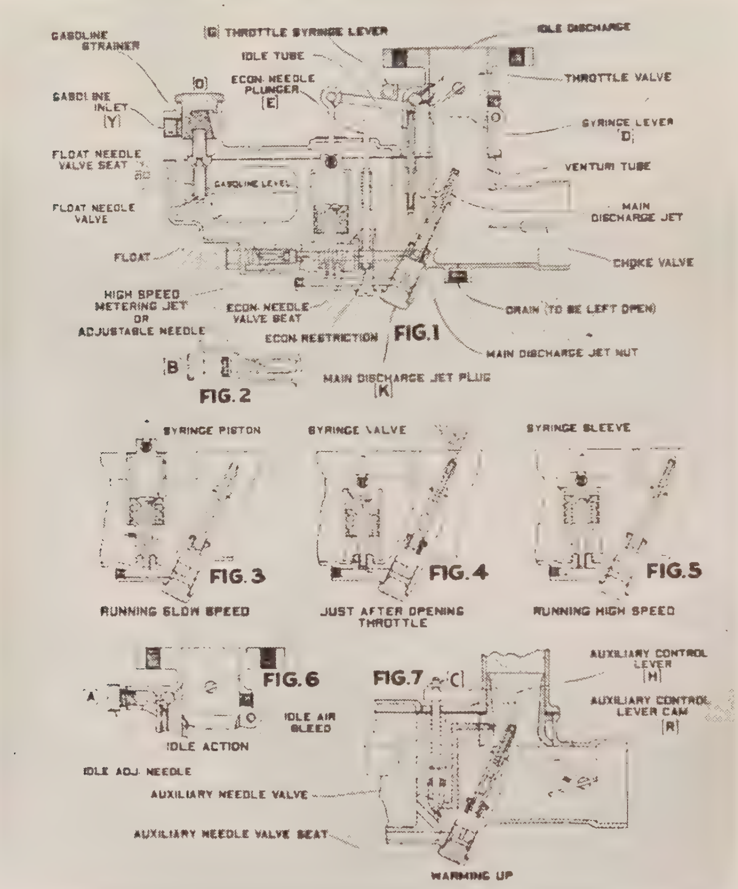
GASOLINE STRAINER
[G] THROTTLE SYRINGE LEVER
IDLE DISCHARGE
IDLE TUBE
[O]
ECON. NEEDLE PLUNGER [E]
THROTTLE VALVE
GASOLINE INLET [Y]
SYRINGE LEVER [D]
FLOAT NEEDLE VALVE SEAT
VENTURI TUBE
GASOLINE LEVEL
FLOAT NEEDLE VALVE
MAIN DISCHARGE JET
FLOAT
CHOKE VALVE
C
HIGH SPEED METERING JET OR ADJUSTABLE NEEDLE
ECON. NEEDLE VALVE SEAT
DRAIN (TO BE LEFT OPEN)
ECON. RESTRICTION
FIG. 1
MAIN DISCHARGE JET NUT
B
FIG. 2
MAIN DISCHARGE JET PLUG [K]
SYRINGE PISTON
SYRINGE VALVE
SYRINGE SLEEVE
FIG. 3
FIG. 4
FIG. 5
RUNNING SLOW SPEED
JUST AFTER OPENING THROTTLE
RUNNING HIGH SPEED
FIG. 6
FIG. 7
[C]
AUXILIARY CONTROL LEVER [H]
A
AUXILIARY CONTROL LEVER CAM [R]
IDLE AIR BLEED
IDLE ACTION
IDLE ADJ. NEEDLE
AUXILIARY NEEDLE VALVE
AUXILIARY NEEDLE VALVE SEAT
WARMING UP

Fig. 4.—Sectional view of carburetor. From insert No. 5 to Dyke's Automobile and Gasoline Engine Encyclopedia-Carburetor and Fuel Feed Systems. Stromberg carburetor, 16th edition. Chicago: The Goodheart-Willcox Company, Inc. 1934.

Canlubang motor alcohol, Gasanol, Gastarla, mixtures of alcohol and gasoline, and Alkohl motor fuel were used. (Chart 1). The constituents of the different fuels are as follows:

Canlubang motor fuel

Alcohol (about 95% by volume)	99.00%
Gasoline	0.50%
Aniline	0.50%
Total	100.00%

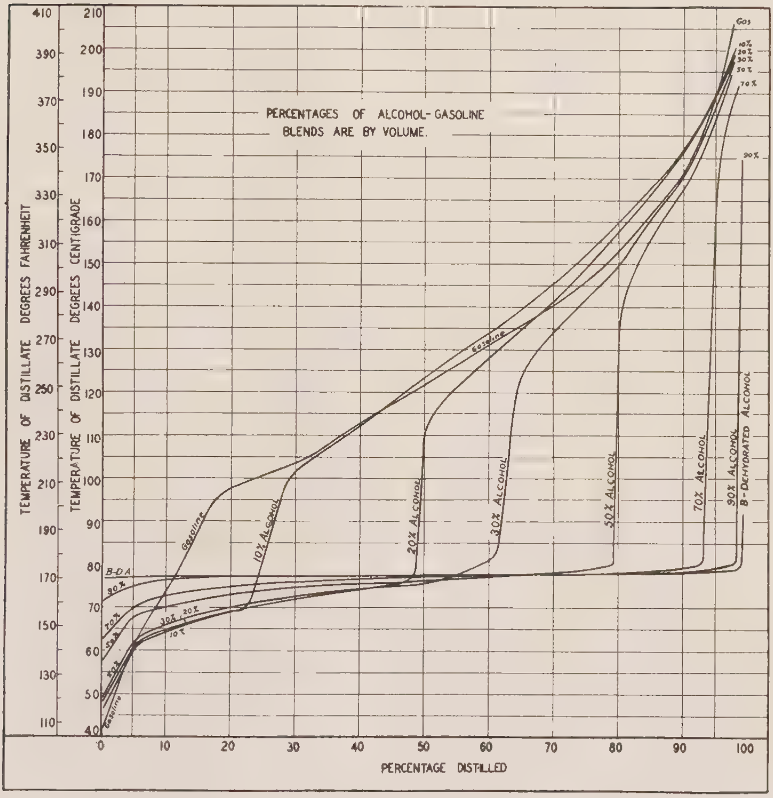

Chart 1.—Distillation curves of fuels used. Gasanol and Gastarla not included.

Gasanol

Alcohol (95.5% by volume)	50	parts
Commercial gasoline	45	”
Sulphuric ether (sp.gr. 0.730)	5	”
Total	100	”

Gastarla

Alcohol 96%	60%
Gasoline	35%
Benzol	5%
Total	100%

Alkohl motor fuel A

Alcohol (about 95% by volume)	97%
Gasoline	3%
Total	100%

Alkohl motor fuel B

Alcohol (about 95% by volume)	95%
Gasoline	5%
Total	100%

Mixture A

Canlubang motor fuel	90	parts
Gasoline (Commercial)	10	”
Total	100	”

Mixture B

Canlubang motor fuel	70	parts
Gasoline (Commercial)	30	”
Total	100	”

Mixture C

Canlubang motor fuel	50	parts
Gasoline (Commercial)	50	”
Total	100	”

Mixture D

Canlubang motor fuel	30	parts
Gasoline (Commercial)	70	”
Total	100	”

Mixture E

B-dehydrated alcohol	20	parts
Gasoline	80	”
Total	100	”

Mixture F

B-dehydrated alcohol	10	parts
Gasoline	90	”
Total	100	”

Two methods were used in determining the mileage of the car, namely, (1) by dividing total distance covered during a given time, which was usually over seventy miles, by the quantity of fuel consumed, and (2) by the use of a Zenith mileage tester.[3] The first method was the one generally followed in this study. The extra fuel used in starting the engine, idling, and backing the car, and the fuel losses due to evaporation and leakage, if any, in fuel passageways were included in this method. The distance traveled was measured in the speedometer and the amount of fuel consumed was determined in the fuel tank by displacement.

The Zenith mileage tester was used when it was desired to measure the mileage over short distances for a definite speed and load. The amount of fuel consumed in starting, idling, and backing the car was disregarded.

The test was divided into groups A and B. In group A, alcohol-gasoline mixtures were used, while in group B, nearly straight alcohol was used. Two years were spent in running the tests in group A and three years in group B.

The car speed varied from 25 miles an hour to 45 miles an hour. The average speed for the tests in and around the College vicinity was 20 to 30 miles an hour. For trips to Canlubang, Santa Cruz, and Manila, the average speed was 37 miles an hour.

RESULTS AND DISCUSSIONS

Group A

Canlubang motor fuel. Canlubang motor fuel was used for about four months. The total distance covered during the test was about 2,000 miles. The average mileage was 8.9 miles per gallon.

The carburetor had to be adjusted several times before satisfactory operation for power and for fuel economy could be attained. The highest mileage obtained was 10.9 miles per gallon and the lowest, 7.8 per gallon. The maximum mileage was recorded when the car was used in a long trip to Manila. (Table 1).

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[3] The Zenith mileage tester consists of a graduated glass bulb of 1/10th of a U. S. gallon capacity, autopulse electric fuel pump, and a three-way control valve, the set mounted in a frame. Rubber tubing of "antimony red" rubber, a material which stands up under the action of gasoline, is included; also two electric leads for operating the electric fuel. Manufactured by Zenith-Detroit Corporation, Detroit, Mich. In addition to 1/10 U. S. gallon burettes, Zenith testers are made with 1/10 imperial gallon ½ liter burettes for foreign use. Published by A. L. Dyke in Supplement to Dyke's automobile and gasoline engine encyclopedia, 1932. 170 p. Chicago: The Goodheart-Willcox Company, Inc.

Engine starting was satisfactory except when the choke was used too much. While the motor was cold, engine acceleration was definitely slower than when gasoline was used. Incipient rusting was noticed in the fuel tank and in the vacuum tank after three months of use with this fuel. The carburetor had to be cleaned twice.

Short tests with the Zenith Mileage Tester showed that it was easily possible to have the mileage decreased by improper setting of the adjustable needle of the high-speed metering jet without noticing any bad engine performance due to a rich mixture. This condition is probably explained by the fact that the range of explosion mixtures of air and alcohol is great.

Gasanol. Gasanol was used for about four weeks. The total distance covered was about 500 miles. The maximum mileage obtained was 15.8 miles per gallon and the minimum, 13.4 miles per gallon. Engine starting was satisfactory, acceleration was definitely better than when using Canlubang motor alcohol, and the pick-up was a little slower than when gasoline was used. After a month of use the carburetor had to be cleaned because of the presence of gummy substances at the end of the jets. Incipient rusting was noticed in the carburetor float.

Gastarla. Gastarla was used for about a month in and around the College of Agriculture. The highest mileage obtained was 15.8 miles per gallon. This was recorded when two trips were made to Santa Cruz, Laguna. The general performance of the engine was nearly the same as when Gasanol was used. The fuel tank showed evidence of heavy rusting at the end of the test.

Alkohl motor fuel A. The total distance covered during about six months using Alkohl motor fuel A was approximately 3,000 miles. The maximum mileage was 11.3 miles per gallon and the minimum, 8.2 miles per gallon. High mileage was recorded during the long trips to Manila where a distance of 94 to 110 miles was covered in one round trip. Engine starting was satisfactory and the acceleration was a little slower than when Gasanol and Gastarla were used. The level of the carburetor float was changed after two months of use. The carburetor developed a small leak when the float level was not right. Corroded metal was found in the carburetor bowl when it was cleaned. The portion of the carburetor that did not come in contact with alcohol fuel likewise showed evidence of rusting. The engine exhaust gases smelled alcoholic on rainy days.

Alkohl motor fuel B. The distance covered during thirty weeks using Alkohl motor fuel B was about 3,200 miles. The average mileage was 9.8 miles per gallon with a maximum of 12.2 miles per gallon during long trips, and a minimum of 9.01 for short distances. The performance of the engine was practically the same as when Alkohl motor fuel A was used. Alcohol fuel penetrated the float of the vacuum tank after six months of use.

Mixture A. Only 400 miles were covered during a period of four weeks using mixture A. Practically no difference was noted in the engine operation with this fuel when compared with those containing less than 10 per cent gasoline. The average mileage obtained was 11.3 miles per gallon.

Mixture B. Tests using mixture B were conducted for two weeks in which a distance of 250 miles was covered. The average mileage obtained was 12.7 miles per gallon. Because no long trip to Manila was made during this period, it was not possible to determine the maximum mileage that could be obtained. Engine acceleration was a little quicker than when mixture A was used. This characteristic was noted on turning curves and in going uphill.

Mixture C. The distance covered for about four weeks using mixture C was 300 miles. No long trip was made during this period. During two trips to Canlubang, Laguna, the mileage obtained was 15.3 miles per gallon. Engine acceleration and pick-up were similar to those obtained with Gasanol and Gastarla. No sign of separation of the fuel constituents was noted at any time during the test. The average mileage was 14.4 miles per gallon.

Mixture D. Two hundred miles were covered in the test using mixture D for a period of two weeks. The average mileage obtained in and around the campus of the College of Agriculture was 15.3 miles per gallon. Separation of gasoline from commercial alcohol was noticed after a sample of the fuel was kept standing over-night. The idling of the engine was irregular when the engine was cold. Satisfactory idling was noticed after the engine had warmed up and a very smooth performance followed after the car had gone over rough roads. It was believed that the shaking of the tank on the rough road resulted in a thorough mixture of the constituents. To prevent separation of alcohol from gasoline, dehydrated alcohol or commercial alcohol blended with benzol or ether may be used.

Mixture E. Only 150 miles were covered using mixture E for less than a week. Two return trips to Canlubang were made using this fuel. The average obtained was 16 miles per gallon. Engine acceleration was definitely better than when Gasanol and Gastarla were used. No separation of the fuel was noted.

Mixture F. During three days of use of mixture F, about 150 miles were covered on an average mileage of 17.4 miles per gallon. One return trip to Manila was made. The performance of the engine using this fuel was so satisfactory that it was considered better than gasoline. Smooth performance was obtained in turning corners and in climbing hills even when the engine was not hot. Unsteady operation and loss of power because of detonation were often noted when commercial gasoline alone was used under the same conditions.

Group B

A total distance of about 24,000 miles was covered from 1936 to 1938, using Alkohl motor fuels A and B. The mileage during this period varied from 8 miles per gallon to 14.7 miles per gallon. The variations were caused by several factors, namely, (*a*) speed and load of the car, (*b*) weather and road conditions (*c*) distance covered during the trip, (*d*) condition of engine, (*e*) condition of tires, and (*f*) driver's skill. (Tables 2, 3, 4, 5).

Speed and load. The effect of speed and load on the total fuel consumption of the car was clearly shown during the long trips to Manila and in climbing hills. A change in average speed from 35-40 miles per hour to 40-45 decreased the mileage from 4 to 10 per cent. With the speed more or less constant, the decrease in mileage owing to additional load of about 300 pounds was about 3 per cent. Short tests in climbing hills indicated marked increase in total fuel consumption when the speed and load were increased.

Weather and road conditions. The mileage obtained on rainy days was slightly lower than on clear and bright days. It was difficult, however, to note the definite effects of weather condition on the mileage because the speed of driving was reduced when it was rainy. The slippery condition of the road also made it impossible to drive with a uniformly moderate speed.

Distance covered during the trip. The average mileage obtained as affected by the distance traveled is shown in table 6. Four conditions were noted, namely, (*a*) driving in and around Los Baños and College vicinity, (*b*) round trip from College to Canlubang, Laguna, (*c*) round trip from College to Santa Cruz, Laguna, and (*d*) round trip from College to Manila and beyond.

Driving in and around the College Campus required more frequent starting and stopping for a given distance than when driving far, as in trips to Canlubang, Santa Cruz, and Manila. The distance covered in one day averaged only from 8 to 15 miles and required starting from seven to twelve times. The trips were usually short being less than a mile each. A distance of about 40 yards was used for backing every time the car was put in the garage or parked in the Engineering building. The tank was refilled every four or five days. The average mileage obtained from a total distance of 7,556 miles was 9.96 per gallon.

Short tests using a Zenith mileage tester on the College roads showed that the mileage increased more than 10 per cent when the fuel consumed for starting and for idling was disregarded. With a warm engine and on straight road the mileage was as high as 12 miles per gallon at a speed of 30 miles per hour.

The distance covered per round trip from Agricultural College to Canlubang varied from 25 to 30 miles. The mileage obtained was found to be 10.52 miles per gallon on a total distance of 2,384 miles. The maximum mileage was about 11.8 miles per gallon at a speed of 35 miles per hour. This was recorded when two trips were made to Canlubang in one day and refueling of the tank was done immediately after the trip was made. Where only one trip was made, the mileage was not computed until after a total distance of about 70 to 80 miles was covered by driving in and around the College for two or three days.

The trips to Santa Cruz, Laguna with an aggregate distance of 3,906 miles, gave an average mileage of 11.23 miles per gallon. This average was not affected very much by the low average obtained in and around the College Campus because the tank was usually refueled the day after a trip was made. At about 30 miles per hour on straight road, the maximum mileage obtained using a Zenith mileage tester was 12.8 miles per gallon.

A total distance of 7,913 miles was covered in trips to Manila and beyond. The average mileage obtained per round trip of 94-110 miles was 12.55 miles per gallon. The lowest mileage obtained was 11.3 miles per gallon and the highest, 14.7 miles per gallon. With only two passengers in the car driven between 40-45 miles per hour, the mileage obtained was about 13.92 miles per gallon. With five passengers and at the same speed, the mileage was only about 12.9 miles per gallon. With a speed of 37 miles per hour, the average was about 13.2 miles per gallon.

On Sundays and holidays when traffic was unusually heavy in Manila, the mileage decreased to about 11.17 miles per gallon.

Condition of engine. A weak battery caused considerable trouble in starting and increased the fuel consumption of the car. Leaky condenser and pitted breaker points made the operation of the engine very irregular and brought about decrease in power. Even with a strong battery the engine was found hard to start on cold mornings if the condenser was leaking and the points were pitted. Weak ignition coil caused the engine to lose power at high speed and to run irregularly at low speed.

Improper adjustment of the carburetor was found the direct cause of poor idling, unsteady operation at all speeds, less power, and high fuel consumption. Maximum fuel economy was obtained if ignition was set a few degrees in advance of the regular setting for gasoline. The greater the amount of alcohol in the mixture the more the ignition was advanced. The performance of the engine using Alkohl motor fuel A was satisfactory when ignition was set 29° before H.E.D.C.

Condition of tires. The use of tires that had already run about 14,000 miles was found unsatisfactory because of the low mileage obtained and of the risk from slippage, puncture, or blow-out. No attempt was made to determine accurately the mileage differences as affected by new and by old tires.

Driver's skill. The use of Alkohl motor fuels A and B requires some knack in starting and in accelerating the car. Under ordinary room temperature, alcohol-air mixture will easily ignite but will fail to continue burning when it is not properly carburated and when it comes in contact with the cold metal of the inlet manifold. A certain amount of choking, determined by experience, facilitated starting even when the atmospheric temperature was as low as 21°C. By carefully observing the engine behavior one can easily tell how much and how long the choking must be continued in order to attain an engine performance that is satisfactory in power and acceleration. The writer found that a period of from one to three minutes of partial choking was needed before the experimental car developed good pick-up and power. The length of time was affected by carburetor adjustment, weather condition, nature and grade of road, and condition of battery, condenser, and breaker points.

General behavior of engine

Starting. No difficulty in starting was observed even when the operating temperature was as low as 21°C. The use of Alkohl motor fuels A and B required skill in operating the choke for starting the engine and for maintaining constant operation on moist days and when the motor was cold. The greater the proportion of gasoline present in the fuel, the less was the time necessary for choking. Most of the difficulties reported by drivers regarding poor engine starting with alcohol may be traced to improper carburetion and ignition adjustments, weak battery, pitted breaker points, faulty condenser and coil, and wrong handling of choke.

Acceleration. Engine pick-up on fuels containing less than 10 per cent gasoline was definitely a little slower than on straight gasoline. The time needed for accelerating to high speed after rounding curves was generally longer than when gasoline was used. With proper carburetor and ignition setting, steady operation was maintained with any desired load and at any speed.

Power. The engine power was not determined by dynamometer test. The performance of the car when alcohol fuel or gasoline was used showed no appreciable differences under varying loads and speeds on level ground and uphill grades. Detonation was never in evidence when alcohol fuels were used. A cold engine using Alkohl motor fuels A and B generally lost power in rounding curves. The engine setting for power that brought about satisfactory performance in alcohol fuels required carburetor adjustment that gave a slightly lean mixture under ordinary driving speeds and a rich mixture in going uphill or in attaining quick acceleration. This was accomplished in the experimental car by partially pulling the choke whenever extra power was needed.

Engine wear. The engine was overhauled after running 28,734.3 miles (45,974.9 km.) on alcohol fuels for a period of four years. The carbon present in the cylinder head and piston heads was not greater than the amount noted when the engine covered 10,678.3 miles (18,085.3 km.) on gasoline for a period of three years. The cylinders showed no evidence of rusting or corrosion. The piston rings were bright and had uniform wear. No part of the pistons or of the cylinders indicated overheating. Not a single valve or piston ring was found sticking. Valve seats and valve stems were not corroded. The intake and the exhaust manifolds disclosed no cracks or rusting. The muffler was not damaged but it was rusted on the outside.

Corrosion. Rusting was very much in evidence in those parts of the fuel passageways which were made of galvanized iron and cast iron. Materials made of copper were not affected.

Economy of operation. The principal factors which affected fuel economy under a certain load and at a certain speed were carburetor and ignition adjustments. The mileage definitely increased as the amount of gasoline in the mixture was increased. The rate of increase in mileage per given increase in the amount of gasoline present in the mixture was not found uniform in this study because the tests were not carried out under the same conditions as regards speed of car, load of car, and course taken.

CONCLUSIONS

The De Soto De Luxe Sedan (1929 model) used in this study performed very satisfactorily when run for over 50,000 kilometers on alcohol fuels for a period of five years. No difficulty in starting was encountered except when the engine carburetion and ignition systems were faulty and when the driver improperly used the choke. Constant operations were maintained at various loads and speeds. As much power as could be produced with gasoline was obtained with alcohol fuels. No sticking of the valves or of the piston rings was noted. Fuel passageways that were made of galvanized iron rusted.

The mileage increased as the amount of gasoline in the mixture was increased. The decrease in mileage due to extra fuel consumed for starting the car, idling, backing, and to losses by evaporation and leakage if any, varied from 5 to 16 per cent.

Proper utilization of nearly straight alcohol as motor fuel demands care not only in properly adjusting the carburetion and ignition systems of an engine but also in manipulating the parts which control these systems so as to bring about smoothness in engine operation, great power, and maximum fuel economy.

TABLE 1

Mileage obtained for the different fuels used

FUELS	APPROXIMATE DISTANCE COVERED	LENGTH OF TEST	MILEAGE	
	miles	*weeks*	*mi./gal.*	*km./liter*
Canlubang Motor Alcohol ..	2,000	16	8.9	3.78
Gasanol	400	4	14.3	6.09
Gastarla	350	4	14.5	6.17
Alkohl motor fuel A	3,000	24	9.7	4.12
Alkohl motor fuel B	3,200	30	9.8	4.17
Mixture A	400	4	11.3	4.81
" B	250	2	12.7	5.40
" C	300	4	14.4	6.12
" D	200	2	15.3	6.51
" E	150	1	16.0	6.80
" F	150	1	17.4	7.40

TABLE 2

Mileage obtained monthly from 1936 to 1938, inclusive

MONTH	YEAR	DISTANCE TRAVELED	FUEL CONSUMED	MILEAGE		REMARKS
		miles	*liters*	*km./l.*	*mi./gal.*	
January .	1936	197.5	88.0	3.61	8.49	One-half month used. Rainy and cold. No long trip.
	1937	839.0	280.0	4.82	11.33	Three trips to Manila and three trips to Sta. Cruz and Canlubang.
	1938	822.2	290.0	4.56	10.73	Two trips to Manila and three to Canlubang.
February	1936	701.9	262.5	4.31	10.12	Four long trips to Manila, Cavite and Rizal.
	1937	869.4	284.0	4.93	11.57	Three trips to Manila, one in Calamba and Sta. Cruz.
	1938	789.3	280.0	4.54	10.67	Two trips to Manila and three to Canlubang.
March ..	1936	419.8	155.0	4.25	9.98	One long trip to Manila.
	1937	752.1	246.5	4.91	11.54	One trip to Manila and four trips to Sta. Cruz and San Pablo.
	1938	431.4	157.5	4.42	10.40	Two trips to Manila and one to Canlubang. Engine was overhauled and car renovated from March 14 to April 3.
April ...	1936	415.0	162.0	4.12	9.69	No long trip.
	1937	695.8	240.5	4.66	10.95	Two trips to Manila and one to Calamba.
	1938	673.3	236.0	4.59	10.78	Two trips to Manila and three to Canlubang and Sta. Cruz.
May	1936	379.9	133.0	4.59	10.79	Two long trips to Manila.
	1937	871.6	256.5	5.46	12.85	Three trips to Manila and four trips to Sta. Cruz.
	1938	902.8	309.5	4.69	11.03	Four trips to Manila, two to Canlubang and two to Sta. Cruz.
June	1936	446.7	185.0	3.88	9.13	No long trip. Much rain. Carburetor leaked.
	1937	1,119.2	367.5	4.90	11.52	Four trips to Manila and six trips to Sta. Cruz.
	1938	487.4	187.0	4.19	9.87	No long trip.

TABLE 2 (continued)

Mileage obtained monthly from 1936 to 1938, inclusive

MONTH	YEAR	DISTANCE TRAVELED	FUEL CONSUMED	MILEAGE		REMARKS
		miles	*liters*	*km./l.*	*mi./gal.*	
July	1936	437.6	145.5	4.84	11.37	Two trips to Canlubang, Sta. Cruz, and Manila.
	1937	1,036.7	329.0	5.07	11.93	Four trips to Manila and four trips to Sta. Cruz and Canlubang.
	1938	793.8	273.0	4.68	11.00	Two trips to Malolos, two to Sta. Cruz, two to Canlubang.
August .	1936	383.2	143.5	4.30	10.11	Plenty of rain. No long trips. New pairs of tires.
	1937	774.1	255.5	4.88	11.46	Two trips to Manila and three to Calamba and Canlubang. Much rain.
	1938	952.7	342.0	4.48	10.53	One trip to Malolos and four to Sta. Cruz.
September	1936	448.1	156.0	4.62	10.86	No long trip. Very rainy.
	1937	953.4	296.5	5.17	12.16	Four trips to Manila and four trips to Sta. Cruz.
	1938	681.0	257.5	4.26	10.01	Two trips to Sta. Cruz.
October .	1936	551.8	184.0	4.83	11.34	Short trips to Canlubang and Sta. Cruz. Moderate rain. One stormy day.
	1937	894.3	285.0	5.05	11.86	Four trips to Manila and two to Sta. Cruz.
	1938	947.8	304.0	5.01	11.78	Two trips to Manila and three to Sta. Cruz.
November	1936	670.4	222.0	4.86	11.42	One long trip to Manila. One to Sta. Cruz. Moderate rain.
	1937	691.7	228.0	4.88	11.46	Two trips to Manila, very rainy; and two, to Sta. Cruz. Storm.
	1938	—	—	—	—	Car was not usd for experiment. Trip to Mindanao for one month.
December	1936	514.0	174.0	4.75	11.18	One trip to Sta. Cruz and Manila. Little rain.
	1937	816.2	292.5	4.50	10.58	One trip to Manila, two to Sta. Cruz, and one to Canlubang. Storm.
	1938	605.3	194.0	5.02	11.80	Two trips to Manila and two to Canlubang.

TABLE 3

Mileage obtained by the years

ITEMS	YEARS			
	1936	1937	1938	1936 1937 1938
Total distance covered				
in kilometers (approx.)	8,954	16,593	13,011	38,558
in miles	5,565	10,313	8,087	23,965
Total amount of Alkohl fuel used				
in liters	2,010	3,361	2,830	8,201
in U.S. gallons (approx.)	531	889	748	2,161
Mileage				
in km./liter	4.45	4.93	4.59	4.70
in mi./gallon	10.47	11.60	10.81	11.05
Number of long trips to Manila and beyond	11	33	19	63

TABLE 4

Computation of the weighted mean by one-half mile per gallon interval

CLASS LIMITS (1)	MIDDLE VALUE (m) (2)	FREQUENCY (f) (3)	COLUMN (2) TIMES (3) (fm) (4)
8.00 and under 8.50	8.25	10	82.50
8.50 ” ” 9.00	8.75	9	78.75
9.00 ” ” 9.50	9.25	26	240.50
9.50 ” ” 10.00	9.75	20	195.00
10.00 ” ” 10.50	10.25	53	543.25
10.50 ” ” 11.00	10.75	37	397.75
11.00 ” ” 11.50	11.25	23	258.75
11.50 ” ” 12.00	11.75	28	329.00
12.00 ” ” 12.50	12.25	16	196.00
12.50 ” ” 13.00	12.75	18	229.50
13.00 ” ” 13.50	13.25	19	251.75
13.50 ” ” 14.00	13.75	5	68.75
14.00 ” ” 14.50	14.25	2	28.50
		226	2,900.00

$$M = \frac{2,900}{266} = 10.90$$

TABLE 5

Computation of the weighted mean by one mile per gallon interval

CLASS LIMITS (1)	MIDDLE VALUE (m) (2)	FREQUENCY (f) (3)	COLUMN (2) TIMES (3) (fm) (4)
8.00 and under 9.00	8.5	19	161.50
9.00 " " 10.00	9.5	46	437.00
10.00 " " 11.00	10.5	90	945.00
11.00 " " 12.00	11.5	51	586.50
12.00 " " 13.00	12.5	34	425.00
13.00 " " 14.00	13.5	24	324.00
14.00 " " 15.00	14.5	2	29.00
		266	2,908.00

$$M = \frac{2{,}908}{266} = 10.93$$

TABLE 6

Mileage under different conditions

PLACE	APPROXIMATE DISTANCE PER TRIP	TOTAL DISTANCE TRAVELED	MILEAGE (SIMPLE MEAN)	
	miles	*miles*	*mi./gal.*	*km./liter*
Los Baños and College	1 to 10	7,556	9.96	4.23
Canlubang, Laguna	25 - 30	2,384	10.52	4.47
Sta. Cruz, Laguna	50 - 60	3,906	11.23	4.77
Manila and beyond	94 - 110	7,913	12.55	5.33

A STUDY OF ROOT NODULE BACTERIA OF CERTAIN LEGUMINOUS PLANTS[1]

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WITH TWO TEXT FIGURES

Although the bacteria that work symbiotically with the legumes belong to morphologic species like *Rhizobium leguminosarum* Frank, it is now generally accepted that the different species exhibit biologic specialization. This means that the species are composed of varieties, strains, or races, each of which will grow only on a legume with which it is associated or on a group of more or less closely related legumes.

The knowledge of the existence of biologic forms of the legume bacteria is useful in selection and cultivation of a legume crop for green manuring, in inoculation with the legume bacteria, and in the differentiation of the members of a cross-inoculation group. The legume whose nodule organism possesses a high nitrogen-fixing power would be valuable for green manuring.

Very little work has been done on symbiotic nitrogen fixation in the Philippines. Dinglasan (1936) of the College of Agriculture found greater nodule formation in unsterilized soil than in sterilized.

The objects of the work were to study: (*a*) the morphological, physiological, and cultural characteristics of root-nodule organisms, (*b*) their ability to cross-inoculate other legumes, and (*c*) their nitrogen-fixing capacity.

MATERIALS AND METHODS

Materials. The plants used in this investigation were: mungo (*Phaseolus aureus* Roxb.), lima bean (*Phaseolus lunatus,* Linn.), tapilan (*Phaseolus calcaratus* Roxb.), peanut (*Arachis hypogaea* Linn.), cowpea [*Vigna sinensis* (Linn.) Savi.], soybean [*Glycine max* (Linn.) Merr.], and calopogonium (*Calopogonium muconoides* Desv.). The seeds were kindly furnished by the Division of Farm Crops of the Department of Agronomy. They were grown in the experimental garden of the Department of Soils, where they were given the necessary cultivation and care.

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[1] Experiment Station contribution No. 1303. Read before the Fifth Philippine Science Convention, Feb. 24, 1939.

Methods. In an attempt to isolate in pure cultures the different legume organisms and to study their morphological, cultural, and physiological characteristics and make other biological tests, the methods suggested by Fred and Waksman (1928) were followed. The Kjeldahl method (1930) for total nitrogen determination in the nitrogen-fixation tests was used.

RESULTS AND DISCUSSIONS

Morphology. Table 1 shows the size and shape of the various strains of nodule bacteria. Efforts to stain flagella by means of Loeffler's stain did not give a positive result.

Stained mounts from three weeks old cultures showed that the cells were coccoid in shape. This change from rod-shaped (48-hour-old cultures) to coccoid (3 weeks old) seems to confirm the claim of earlier workers that the rhizobia exhibit pleomorphism. This characteristic coupled with the fact that the nodule bacteria produce involution forms on different sugar media (Whiting, Fred, and Helz, 1936) and on media containing certain chemicals (Alicante, 1926) suggest that differentiation based on size and shape is not reliable.

Cultural characters

Test tube cultures. A summary of the more important characters is shown in table 2 and fig. 1. A comparison of the cultural characters of the seven strains grown on mannitol agar slant and incubated at 27°C. showed that all except the calopogonium strain resembled each other in form, elevation, and luster of growth. Slime production and abundant growth were common in the soybean and mungo cultures. Wright (1925) observed some strains of soybean nodule bacteria which showed moderate to abundant, raised, and glistening growth. The strains of cowpea, tapilan, and peanut showed moderate growth, but the calopogonium strain exhibited scanty, filiform, raised, and whitish streaks on mannitol agar slant.

During the progress of the work, it was repeatedly noted that the clumps produced by the strains having considerable slime were broken in water only when they were vigorously shaken. The strains which had little slime, however, readily formed uniform suspension in water.

Plate cultures. A study of both surface and buried colonies was made on platings of the cultures and reisolations from nodules. In all plate cultures, Congo red mannitol agar was used.

Bacterial colonies, usually discernible in three to four days, were large enough to transfer within ten days. All colonies of the seven strains were circular, raised, smooth, moist, and transparent to translucent. The edges were entire. The nodule organisms did not absorb the Congo red dye. Colored colonies indicated contamination.

Variations were noticed in the size of colonies. Actual measurements in plate cultures incubated for one week at 27°C. showed that the soybean and tapilan nodule bacteria reached a diameter of 2 to 4 mm.; the cowpea, mungo, peanut, and calopogonium nodule bacteria, 1 to 2 mm.; and the lima bean nodule bacteria, 0.5 to 1.5 mm.

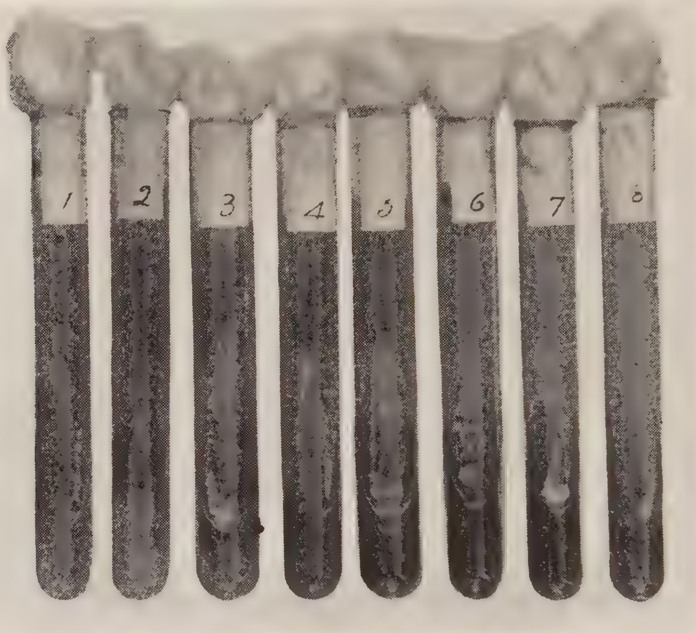

Fig. 1.—Streak cultures of the organisms on mannitol agar slant with brom-thymol-blue indicator. 1, tapilan; 2, cowpea; 3, lima bean; 4. peanut; 5, mungo; 6, soybean; 7, calopogonium; and 8, control. Note the visible change of cultures 1, 2, and 3. Age, 8 days.

Buried colonies were very dense, usually spindle or lens-shaped with acute angles at the points.

Physiology

The acid-forming characteristics of the nodule organisms are presented in tables 3a and 3b. In table 3a, the cowpea, tapilan, and mungo strains are shown as strongly acid-forming; the lima bean, peanut, and soybean strains, intermediate; and the calopogonium strain, very slightly acid-forming. Baldwin and Fred (1927) made similar observations in many cultures of cowpea and soybean nodule bacteria. The clearing of the medium may be attributed to decomposition of calcium carbonate as a result of organic acids liberated in the fermentation of the glucose.

Table 3b shows the acid-forming characteristics of the nodule organisms in mannitol slant agar. With the exception of the nodule bacteria of mungo, the cowpea and tapilan strains maintained their strongly acid-forming characteristic, although with less rapidity. The nodule bacteria of lima bean and peanut also maintained their intermediate acid-forming property, whereas, the soybean nodule bacteria became slightly acid-forming.

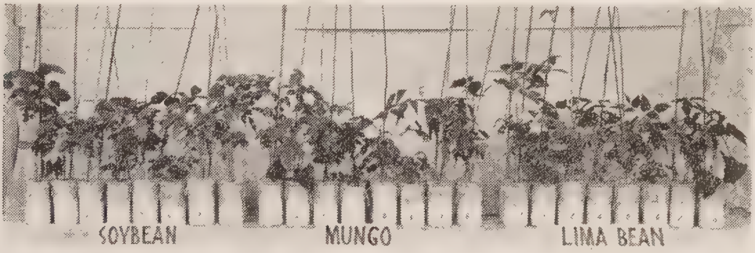

Fig. 2.—Cross-inoculation experiment. 1, soybean; 2, lima bean; 3, mungo; 4, peanut; 5, cowpea; 6, calopogonium; 7, tapilan; 8, control, inoculated with the nodule bacteria of soybean on the group at the left, mungo strain in the center, and lima bean strain at the right. Age, 1½ months.

Walker and Brown (1930) observed that the alfalfa strains produced an acid reaction, and the soybean strain, an alkaline.

Generally, the power of the strains to produce a visible change in the color of the medium was slower in the mannitol agar slant than in the glucose agar. This observation seemed to show that all the nodule bacteria studied ferment glucose more rapidly than mannitol.

Cross-inoculation

A summary of the results of cross-inoculation of the seven species of legumes are shown in table 4 and fig. 2.

The group to which the calopogonium belongs is not known. Carroll (1934a) classified the soybean nodule and the crotalaria nodule bacteria under the cowpea group. According to him, Walker (1928) placed these two nodule organisms under separate groups.

From the results in table 4, the writers consider the soybean and cowpea groups as distinct and separate.

Inasmuch as species differentiation in the genus *Rhizobium* is based on ability to inoculate plants, nodules on inoculated plants were counted as a measure of host susceptibility. Allen and Allen (1936) remarked that "plus signs have been used to indicate the extent of nodulation, but explanatory remarks have not elucidated whether the plus signs signified one nodule or two dozen nodules. Although it is admitted that too much significance cannot be placed upon the actual numbers of nodules produced on a plant by a given culture, yet in instances of this nature, numbers are of more value than symbols."

When the nodule organism of cowpea was used for inoculating soybean, no evidence of nodule formation was observed in the two trials made. When the soybean organism was used on cowpea, however, the formation of nodules was noted. Actual counting showed that only four nodules in the first trial and three in the second were produced. This slight nodulation suggests that cowpea plants are not readily susceptible to infection by the soybean nodule bacteria. This finding is in accord with the results secured by Allen and Allen (1936).

The nodule bacteria of tapilan and peanut failed to form nodules on the roots of soybean. On the other hand, when the nodule organism of soybean was inoculated on tapilan and peanut, nodules were formed. Actual counts showed a few nodules on the roots of peanut and many on tapilan, which is apparently susceptible to infection by the soybean-nodule organisms.

The nodule bacteria of lima bean and mungo when inoculated on soybean produced a few nodules. The soybean-nodule bacteria produced more nodules on mungo than on lima bean.

Cases of reciprocity and non-reciprocity of the nodule bacteria of soybean and cowpea have been reported by Leonard (1923), Sears and Carroll (1927), Carroll (1934a), and others.

The organism isolated from the nodules of calopogonium formed abundant nodules when inoculated on soybean or cowpea. Its cultural and physiological characters, however, show differences from the cowpea- or soybean-nodule bacteria. For this reason, further studies on the physiological characters of the calopogonium strain seem necessary before a definite classification can be made.

Nitrogen fixation

The results on symbiotic nitrogen fixation are shown in tables 5a and 5b.

Two sets of cultures, one month and two months old, were made. This was originally planned in order to find out if there is any significant increase in nitrogen fixed as the plants grow older. In all cases, the inoculated cultures harvested after two months showed a higher amount of fixed nitrogen than those harvested after one month. The increase in nitrogen fixation may probably continue up to the stage when the plants begin to produce flowers or blossoms, provided all factors are favorable. According to the "carbohydrate hypothesis" of Allison (1935), during the blossoming period the carbohydrate in photosynthesis is mostly used by the top for the proper development of fruits and seeds. Hence, only a little of it goes to the roots and root nodules to result in reduced microbial activity.

The data further show that all of the species of legumes inoculated varied considerably in the amount of fixed nitrogen. The bacteria on members of the cowpea group, however, were more efficient in fixing atmospheric nitrogen than the soybean group. But when the members of the cowpea group were compared with one another, they varied considerably in their efficiency to fix atmospheric nitrogen.

Carroll (1934) observed that certain strains of nodule bacteria belonging to the cowpea cross-inoculation group showed greater power of nitrogen fixation than other strains in the same group.

It may also be noted that the inoculated calopogonium plants had more nitrogen than the soybean plants. Table 5b gives the amounts of nitrogen fixed in the different legumes. If the individual amounts of fixed nitrogen are compared, cowpea, peanut, and lima bean nodule organisms seem to be more efficient in fixing atmospheric nitrogen than the nodule organisms of soybean, calopogonium, mungo, and tapilan.

Inoculation not only resulted in appreciable increase in fixed nitrogen, but it also increased the yield of dry matter of the plants. In all cases, the inoculated cultures slightly but consistently produced a greater yield of dry-matter than the uninoculated. This conclusion is in agreement with the findings of Whiting and Schoonover (1920), Fred and Bryan (1922), Wright (1925), Fred, Whiting, and Hastings (1926), and Carroll (1934b).

Except in three cases, the writers noted that the more the nodules formed, the higher was the gain in nitrogen. The soybean nodule bacteria were less efficient in fixing atmospheric nitrogen than any of the other nodule organisms studied.

SUMMARY AND CONCLUSIONS

1. The nodule bacteria of seven tropical legumes: mungo (*Phaseolus aureus* Roxb.), lima bean (*Phaseolus lunatus* Linn.), tapilan (*Phaseolus calcaratus* Roxb.), peanut (*Arachis hypogaea* Linn.), cowpea [*Vigna sinensis* (Linn.) Savi.], soybean [*Glycine max* (Linn.) Merr.], and calopogonium (*Calopogonium muconoides* Desv.) were isolated, and their morphological, physiological, and cultural characteristics studied.

2. Very little variation was noted in the morphology of the seven strains. Some differences in their cultural and physiological characteristics were noted. Growth in mannitol agar slant was moderate for the cowpea, tapilan, and peanut organisms; abundant for the lima bean, mungo, and soybean nodule organisms; and scanty for the calopogonium strain.

3. The cowpea, tapilan, and mungo root-nodule organisms were strongly acid-forming; the lima bean, peanut, and soybean organisms, intermediate; and the calopogonium strain, very slightly acid-forming.

4. The nodule bacteria of cowpea were not capable of infecting the roots of soybean. When the soybean nodule organisms were used for inoculating cowpea, only very few nodules were produced. It seems that the nodule bacteria of cowpea and soybean are distinct and separate. Members of the cowpea group cross-inoculate.

5. The nodule bacteria of tapilan and peanut failed to cause nodulation on soybean.

6. The nodule bacteria of calopogonium produced fairly abundant nodules on soybean and cowpea.

7. The seven strains of nodule bacteria studied varied in their ability to fix atmospheric nitrogen.

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TABLE 1

Morphology of 48-hour-old cultures of the seven strains of nodule bacteria

STRAINS OF NODULE BACTERIA	AVERAGE SIZE	SHAPE
	μ	
Cowpea	1.48 × 0.88	Rod-shaped with rounded ends
Tapilan	1.56 × 0.70	
Lima bean	1.41 × 0.68	
Peanut	1.45 × 0.66	
Mungo	1.29 × 0.61	
Soybean	1.49 × 0.66	
Calopogonium	1.23 × 0.74	

TABLE 2

Cultural characteristics of seven strains of nodule bacteria after one week of incubation at 27°C.

STRAIN OF NODULE BACTERIA	GROWTH ON MANNITOL AGAR SLANT
Cowpea	Moderate, echinulate, raised, glistening. Little slime.
Tapilan	Moderate, echinulate, raised, glistening. Considerable slime.
Lima bean	Abundant, echinulate, raised, glistening. Little slime.
Peanut	Moderate, echinulate, raised, glistening. Considerable slime.
Mungo	Abundant, echinulate, raised, glistening. Considerable slime.
Soybean	Abundant, echinulate, raised, glistening. Considerable slime.
Calopogonium	Scanty, filiform, raised, whitish. Little slime.

TABLE 3a

Fermentation characteristics of seven strains of nodule bacteria when grown on glucose agar slant with brom-thymol-blue as indicator, pH 7.0.

STRAINS OF NODULE BACTERIA	NUMBER OF DAYS TO START YELLOWING [a]	NUMBER OF DAYS TO COMPLETE YELLOWING [a]	REMARK [b]
Cowpea	1-2	1	++++
Tapilan	1-2	1-2	++++
Lima bean	3-4	2-3	+++
Peanut	1-3	1-3	+++
Mungo	1-2	1-2	++++
Soybean	1-3	2-3	+++
Calopogonium	6-11	5-14	+

[a] Range of five trials.
[b] ++++ Strongly acid-forming.
+++ Mediumly acid-forming.
++ Slightly acid-forming.
+ Very slightly acid-forming.

TABLE 3b

Fermentation characteristics of seven strains of nodule bacteria when grown on mannitol agar slant with brom-thymol-blue as indicator, pH 7.0.

STRAINS OF NODULE BACTERIA	NUMBER OF DAYS TO START YELLOWING [c]	NUMBER OF DAYS TO COMPLETE YELLOWING [c]	REMARK [d]
Cowpea	2-5	5-16	++++
Tapilan	2-4	3-15	++++
Lima bean	4-7	5-18	+++
Peanut	4-5	11-27	+++
Mungo	4-7	13-28	+++
Soybean	4-12	18-45	++
Calopogonium	9-24	—	+

[c] Range of five trials.
[d] ++++ Strongly acid-forming.
+++ Mediumly acid-forming.
++ Slightly acid-forming.
+ Very slightly acid-forming.

TABLE 4

Results of cross-inoculation tests with root-nodule bacteria on seven species of legumes

SOURCE OF INOCULUM	PLANTS INOCULATED	FIRST TRIAL, ONE MONTH OLD		SECOND TRIAL, TWO MONTHS OLD	
		Number of nodules on 4 plants	Remark [e]	Number of nodules on 4 plants	Remark [e]
Soybean	Lima bean ..	4	+	10	+
	Tapilan	42	++++	25	++
	Cowpea	4	+	3	+
	Calopogonium	48	++++	14	++
	Mungo	28	+++	18	++
	Peanut	7	+	10	+
	Control	0	—	0	—
Cowpea	Soybean	0	—	0	—
	Lima bean ..	21	++	30	++
	Tapilan	18	++	10	+
	Calopogonium	11	++	8	+
	Mungo	12	++	40	+++
	Peanut	10	+	15	++
	Control	0	—	2	[f]
Lima bean ..	Soybean	8	+	25	++
	Tapilan	37	+++	51	++++
	Cowpea	25	++	58	++++
	Calopogonium	54	++++	45	++++
	Mungo	49	++++	87	+++++
	Peanut	10	+	4	+
	Control	5	[f]	0	—
Tapilan	Soybean	0	—	0	—
	Lima bean ..	25	++	28	++
	Cowpea	38	+++	56	++++
	Calopogonium	60	++++	22	++
	Mungo	33	+++	59	++++
	Peanut	5	+	21	++
	Control	0	—	0	—
Mungo	Soybean	3	+	8	+
	Lima bean ..	25	++	53	++++
	Tapilan	23	++	52	++++
	Cowpea	46	++++	57	++++
	Calopogonium	46	++++	53	++++
	Peanut	5	+	10	+
	Control	0	—	0	—
Peanut	Soybean	0	—	0	—
	Patani	47	++++	49	++++
	Tapilan	53	++++	72	+++++
	Cowpea	33	+++	58	++++
	Calopogonium	51	++++	53	++++
	Mungo	10	+	38	+++
	Control	0	—	0	—
Calopogonium	Soybean	5	+	10	+
	Patani	50	++++	28	++
	Tapilan	20	++	36	+++
	Cowpea	26	++	25	++
	Mungo	20	++	12	++
	Peanut	12	++	10	+
	Control	0	—	0	—

[e] +++++ Very highly susceptible.
++++ Highly susceptible.
+++ Susceptible (Mean, 33 nodules).
++ Moderately susceptible.
+ Doubtful.
— Resistant.

[f] Contamination.

TABLE 5a

Nitrogen fixation by root-nodule bacteria in inoculated legumes (one month old)

STRAIN OF NODULE BACTERIA	NODULE NUMBER	AIR-DRY WT. OF 4 PLANTS	NITROGEN	TOTAL NITROGEN IN PLANTS	AMOUNT OF NITROGEN FIXED[g]
		gm.	*per cent*	*mgm.*	*mgm.*
Soybean					
Uninoculated .	0	0.4008	2.86	11.45	
Inoculated	3	0.4152	3.11	12.92	1.47
Calopogonium					
Uninoculated .	0	0.1290	2.72	3.51	
Inoculated	54	0.2188	2.99	6.54	3.03
Tapilan					
Uninoculated .	0	0.2890	1.80	5.21	
Inoculated	60	0.4960	2.22	10.02	4.81
Mungo					
Uninoculated .	0	0.1800	2.85	5.14	
Inoculated	47	0.3152	3.40	10.73	5.59
Cowpea					
Uninoculated .	0	0.7474	2.59	19.37	
Inoculated	58	0.7568	3.35	25.32	5.95
Lima bean					
Uninoculated .	0	2.2090	2.60	57.37	
Inoculated	100	2.2156	3.04	67.44	10.07
Peanut					
Uninoculated .	0	1.8722	3.69	69.16	
Inoculated	60	2.1064	4.06	85.48	16.32

[g] Inoculated minus uninoculated.

TABLE 5b

Nitrogen fixation by root-nodule bacteria in inoculated legumes (two months old)

STRAIN OF NODULE BACTERIA	NODULE NUMBER	AIR-DRY WT. OF 4 PLANTS	NITROGEN	TOTAL NITROGEN IN PLANTS	AMOUNT OF NITROGEN FIXED [h]
		gm.	*per cent*	*mgm.*	*mgm.*
Soybean					
Uninoculated .	0	1.1894	2.04	24.20	
Inoculated	39	1.2532	2.34	29.29	5.09
Calopogonium					
Uninoculated .	0	0.2200	2.75	6.05	
Inoculated	69	0.3588	3.17	11.39	5.34
Mungo					
Uninoculated .	0	0.6238	2.69	16.78	
Inoculated	59	0.8426	2.97	25.04	8.26
Tapilan					
Uninoculated .	0	0.8692	1.42	12.33	
Inoculated	58	0.9100	3.02	27.47	15.14
Cowpea					
Uninoculated .	0	1.1496	1.86	21.39	
Inoculated	75	1.6478	2.67	44.06	22.67
Peanut					
Uninoculated .	0	1.4114	2.87	40.50	
Inoculated	76	2.2560	3.11	70.09	29.59
Lima bean					
Uninoculated .	0	2.5224	1.91	48.09	
Inoculated	95	3.8162	2.13	81.32	33.23

[h] Inoculated minus uninoculated.

STUDIES ON THE FERTILIZING VALUE OF MAYON VOLCANO ASH: I. EFFECTS UPON PLANTS OF LIBERAL APPLICATION OF THE VOLCANIC ASH[1]

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WITH THREE TEXT FIGURES

Writers always attribute the good stand of abacá and of other crops in the Bicol peninsula and elsewhere to the volcanic origin of the soil, hence the current belief in the Philippines that Mayon Volcano ash is good for plants. This belief may be correct, but there seems to be a lack of authentic experimental evidence to support it. Moreover, the results of chemical and physical analyses of the fine ejecta of Mayon volcano made by Galvez *et al* (1939) showed, among other things, the absence of nitrogen. The results also showed the presence, in relatively large amounts, of certain mineral constituents that can spoil the physical condition of soils and be toxic to plants as well. For these reasons, experimental evidence from the plants themselves was sought.

A series of culture studies, of which this is a part, was started, the objects being (*a*) to observe the effects upon certain common plants grown in Lipa clay loam of adding relatively large amounts of Mayon Volcano ash, and (*b*) to determine the cause of the effects, harmful or beneficial, of the volcanic ash upon plants. Large quantities of Mayon ash were tried because of lack of marked effects upon certain plants when added to Lipa clay loam in relatively smaller amounts.

This study was conducted in the experimental yard of the Department of Agricultural Botany from September 13, 1938, to November 2, 1938.

MATERIALS, METHODS, AND RESULTS

The culture media. The culture media consisted mainly of Lipa clay loam to which large quantities of Mayon Volcano ash had been added (table A).

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[1] Experiment Station contribution No. 1304. Read before the Los Baños Biological Club on November 17, 1938.

TABLE A

The culture media

CULTURE NO.	MIXTURES OF SOIL AND MAYON ASH
I	14 kgm. air-dry soil—as control
II	½ soil + ½ ash by volume, or 9 kgm. soil + 10 kgm. ash
III	14 kgm. soil + ash 1 cm. thick, or 0.8 kgm.
IV	14 kgm. soil + ash 2 cm. thick, or 1.6 kgm.
V	14 kgm. soil + ash 4 cm. thick, or 3.2 kgm.
VI	14 kgm. soil + ash 6 cm. thick, or 4.8 kgm.
VII	14 kgm. soil + 2 gm. of sulfate of ammonia

The Lipa clay loam used was gathered from an unfertilized lot near the Administration building, pulverized, sieved, and thoroughly mixed. The required amounts of the air-dry soil were placed in tin cans.

The volcanic ash was collected from a field in Albay soon after the recent eruptions of Mayon Volcano in June, 1938. It was brought to the College by Dr. Nicolas Galvez of the Department of Soils. The ash appeared as ordinary cement. Before being used, the volcanic volcanic ash was mixed thoroughly. For purposes of comparative study, the mixture may be considered as sufficiently homogeneous. Galvez (1939) found that the Mayon Volcano ash contained 56.36 per cent silicon dioxide (SiO_2), 19.37 per cent aluminum oxide (Al_2O_3), 0.78 per cent titanic oxide (TiO_2), 8.33 per cent ferric oxide (Fe_2O_3), 0.44 per cent manganese oxide (Mn_3O_4), 8.5 per cent lime (CaO), 1.13 per cent magnesia (MgO), 1.16 per cent potash (K_2O), 2.12 per cent soda (Na_2O), 0.56 per cent phosphorus pentoxide (P_2O_5), 0.4 per cent sulfur trioxide (SO_3), and 0.72 per cent loss on ignition—all in total amounts.

The plants. The four species of plants used were radish, soybean, rice, and corn; although they were grown simultaneously, only one kind was grown in each culture. Three plants were planted in each pot and three pots in each culture type, so that a total of nine plants were grown in each type of culture medium. The plants were grown from seeds which had been soaked in water for thirty-six hours. When the plants were forty-three days of age, they were photographed (figs. 1 to 3) and, three days later, harvested. Unfortunately, the picture of the cultures of radish did not come out well. The experimental data on height of plants, and green weight of tops, are given in relative values of averages in tables 1 and 2.[2]

Care of cultures. In addition to occasional weeding and loosening of the surface soil very little care was given to the cultures. Most of the water for keeping the soil moist came from the rain. Soon after a heavy rain or after watering, a turbid liquid came out of the drainage holes of the cultures that had been supplied with the volcanic ash.

DISCUSSION OF RESULTS

General observation. When the young plants were about fifteen days old, it became evident that the volcanic ash was quite harmful to three of the four species of plants studied. In all of the ash-treated cultures the young radish, rice, and corn plants looked more chlorotic and more markedly stunted than the control plants. The young corn and radish plants were the most seriously affected. In fact, some of the young radish plants died early, presumably from the deleterious action of volcanic ash. The corn plants that received the largest application of volcanic ash were the most chlorotic and the purple color of the stalks extended to the leaf blades. On the other hand, the soybean plants looked normally green and seemed to do equally well both in volcanic ash-treated cultures and in control or untreated cultures. The young soybean plants in culture II, which received the largest amount of volcanic ash, also appeared somewhat stunted in growth.

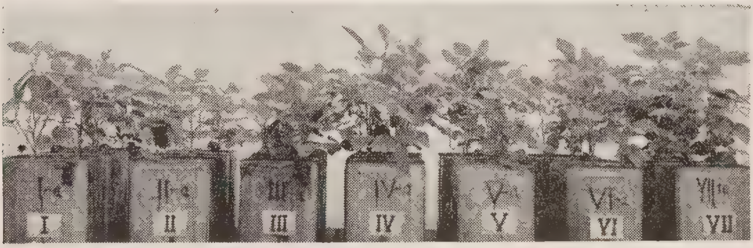

Fig. 1.—Young soybean plants grown in Lipa clay loam to which was added varying amounts of Mayon Volcano ash. Cultures I, soil alone; II, ½ soil + ½ ash; III, soil + ash 1 cm. in thickness; IV, soil + ash 2 cm. in thickness; V, soil + ash 4 cm. in thickness; VI, soil + ash 6 cm. in thickness; and VII, soil + 2 grams ammonium sulfate.

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[2] The mass of original data is on file in the Department of Agricultural Botany.

As the plants grew older, the rice plants, excepting those in culture II, which received the largest application of volcanic ash, began to improve in growth. Some of the forty-three day old rice plants that received volcanic ash appeared as green and healthy as those grown in the unfertilized or untreated cultures. The plants in culture VII, which received only two grams of ammonium sulfate, were greener and better developed than those of the same species in the other cultures in the set. The corn was markedly benefited by the moderate application of ammonium sulfate (fig. 3). A study is now under way to determine whether or not the deleterious effects of Mayon ash will appear again if the culture media are replanted to the same kind of plant.

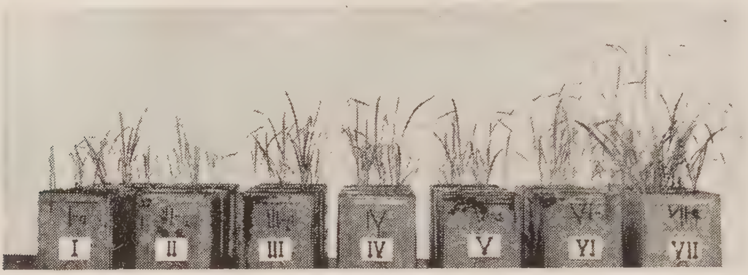

Fig. 2.—Young rice plants grown in Lipa clay loam to which was added varying amounts of Mayon Volcano ash. Cultures I, soil alone; II, ½ soil + ½ ash; III, soil + ash 1 cm. in thickness; IV, soil + ash 2 cm. in thickness; V, soil + ash 4 cm. in thickness; VI, soil + ash 6 cm. in thickness; and VII, soil + 2 grams ammonium sulfate.

Effects of volcanic ash as indicated by height of plants. In table 1 the actual average height of plants in culture I, the untreated culture, was arbitrarily considered as 100, and the rest of the data on the same plant were converted into relative values. This table shows that the average height of the radish, rice, and corn plants in culture I was better than any of those from II to VI. Culture I was the control and contained only Lipa clay loam. Cultures II to VI, however, contained both the soil and certain amounts of the volcanic ash. The decrease in height was, therefore, due to the volcanic ash which might contain certain substances that inhibit growth. It is also quite possible that the addition of liberal amounts of the ash had produced physiologically unbalanced solutions for the young radish, corn, and rice plants.

With the soybean plants, however, the heights of the plants in table 1 show that cultures IV and VI were better than culture I. Probably culture V also would have been better than the control had not one or two plants in it been exceptionally small. Moreover, the soybean plants appeared green throughout the entire period of this study. Therefore, the presence of much volcanic ash in Lipa clay loam did not seem harmful to the young soybean plants.

Table 1 further shows that culture VII which received only two grams of ammonium sulfate was the best in the four sets of cultures. In this culture the plants were taller and greener than any of the similar plants in this study and these facts seem to indicate once more that the Lipa clay loam was deficient in nitrogen, and that the addition of volcanic ash was not enough to counteract the bad effects upon plants of such a deficiency. In this connection, it should be recalled that Galvez *et al* (1939) reported the absence of nitrogen in Mayon ash. Thus, it may be said that the addition of Mayon ash cannot improve the nutritive value of a soil deficient in nitrogen.

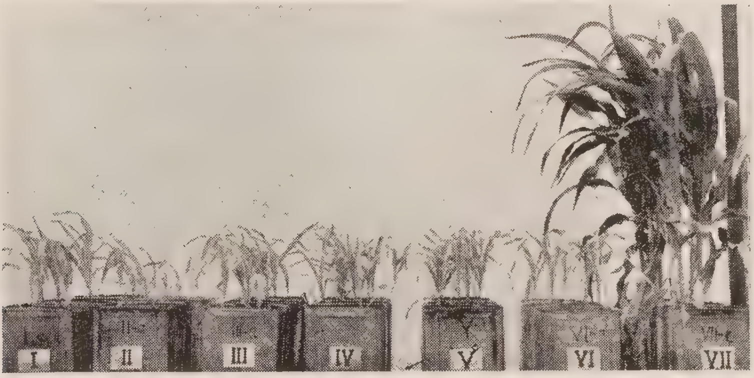

Fig. 3.—Young corn plants grown in Lipa clay loam to which was added varying amounts of Mayon Volcano ash. Cultures I, soil alone; II, ½ soil + ½ ash; III, soil + ash 1 cm. in thickness; IV, soil + ash 2 cm. in thickness; V, soil + ash 4 cm. in thickness; VI, soil + ash 6 cm. in thickness; and VII, soil + 2 grams ammonium sulfate.

Effects of volcanic ash as indicated by green weights of tops. The average data on green weights of tops were also converted into relative values with that of the control taken arbitrarily as 100; the results are given in table 2. This table shows that in terms of the green weight of tops of radish and corn, none of the cultures from II to VI that received volcanic ash were equal to, or better than, the corresponding control or untreated cultures. The plants in culture II, which received the largest application of the volcanic ejecta, were very much lighter than the corresponding plants in culture I. Thus, it appears that the volcanic ash when liberally added to Lipa clay loam deficient in nitrogen was harmful to young radish and corn plants.

In table 2 the yields of tops of some of the ash-treated cultures (II to VI) were better than those of culture I, which had no volcanic ash. It is thus seen that moderate applications of volcanic ash to Lipa clay-loam soil might finally bring about beneficial effects upon certain young plants such as soybean and rice. But for corn and radish plants the addition of any of the amounts of the volcanic ash tried proved quite harmful to the plants. In other words, the Mayon ash when added in moderate amounts to a soil poor in nitrogen was beneficial to some young plants and harmful to other plants.

Probable causes of the effects observed. The mass of evidence on hand seems to show, in a general way, that the more volcanic ash added to Lipa clay loam the greater was the harm done to the young corn, radish, and possibly rice plants. It should also be remembered that culture II, which received the largest amount of ash, contained a mixture of Lipa clay loam and volcanic ash fifty-fifty by volume. The first probable cause of the injury to the plants seems to be the change in the physical character of the original soil used. This was no doubt brought about by an increase in the number of the very fine particles in the solid medium and by the addition of relatively large amounts of aluminum, sodium, and potassium. Galvez (1939) found that the volcanic ash contained, among other things, as much as 19.13 per cent Al_2O_3, 2.12 per cent Na_2O, and 1.16 per cent K_2O. All of these substances when present in large amounts can make a soil compact, and consequently poorly drained and poorly aërated. The poor growth of certain plants may thus be atributed to poor drainage and inadequate aëration.

The second probable cause of the harmful effects might be the change of the chemical composition of the soil medium resulting from the application of a relatively large amount of the volcanic ash. The Mayon ash contained 1.16 per cent of K_2O, so that addition of any large quantity of the volcanic ash to Lipa clay loam,[3] which Enrile

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[3] Samples of the same soil were analyzed by the Department of Agricultural Chemistry and found to contain 0.13 per cent N, 0.20 per cent of P_2O_5, and 0.19 per cent of K_2O.

(1938) found already had sufficient potash but was deficient in nitrogen for upland rice, would produce a soil solution which was physiologically unbalanced. Earlier studies in the Department of Agricultural Botany have shown that the application of potash fertilizer to a soil deficient in nitrogen produced upland rice plants which were always stunted in growth and had extremely chlorotic leaves, and in most cases, the potash-fertilized plants were even poorer than the unfertilized plants.

The third probable cause of the harmful effects upon plants of a heavy application of the Mayon ash to Lipa clay loam may be that it makes the phosphorus content of the soil insoluble. With the addition of much volcanic ash to Lipa clay loam, previously found by Talamisan (1938) to contain sufficient phosphorus for upland rice plants, considerable quantities of calcium, iron, and aluminum were also added. Galvez (1939) found that the volcanic ash contained 19.37 per cent Al_2O_3, 8.33 per cent Fe_2O_3, and 8.5 per cent CaO. It was, therefore, quite possible that the addition of these substances might have made the phosphorus in the original soil unavailable to the young plants by the formation of insoluble compounds with calcium, iron, or aluminum in the soil. This could not, however, be the cause since the soybean plants which also needed phosphorus would have shown a similar injury, but they did not.

As the volcanic ash contained a rather large amount of aluminum, another possible cause of harm to plants is aluminum toxicity. A large amount of soluble salts of this metal is toxic to plants. This could not be the cause either since a liberal application of the volcanic ash could not have produced cases of aluminum toxicity and injured the rice, radish, and corn plants without injuring the soybean.

That the young soybean plants were not always adversely affected by the volcanic ash may be due to the fact that the soybean is a legume, and the bacteria in the root tubercles may have been able to fix atmospheric nitrogen so that the deficiency in nitrogen in the soil solution may have been, at least partly, if not entirely, made up. It would thus seem possible that the soil solution remained more or less well-balanced for this plant, especially in the cultures moderately supplied with the volcanic ash.

If the fairly good growth of the soybean plants in the Mayon ash-treated cultures can be used as a criterion for determining the cause of the injury, it is apparent that the harmful effects upon the young corn, radish, and rice plants of large quantities of volcanic ash are not due to the production of alkaline reaction in the soil, neither are they due to the production of insoluble compounds of phosphorus with calcium, iron, or aluminum, or to aluminum toxicity. Lack of aëration and poor drainage might in a small measure affect the plants, especially the radish, adversely.

It is thus probable that the chief cause of injury to young radish, corn, and possibly rice plants of the addition of a relatively large quantity of the volcanic ash to Lipa clay loam is the production in the soil of a physiologically unbalanced culture solution. The addition of potash to a soil already rich in this plant nutrient but deficient in nitrogen might have been the cause of the stunted growth and the chlorotic appearance of the young rice, corn, and radish plants.

SUMMARY AND CONCLUSIONS

1. This study was carried out to determine (*a*) the effects upon certain common plants of adding relatively large amounts of Mayon Volcano ash to Lipa clay loam and (*b*) the cause of the effects, harmful or beneficial, upon the plants.

2. In general, the more volcanic ash added to Lipa clay loam the greater was the harm (stunted growth and chlorotic leaves) to the young corn, radish, and possibly rice plants. The Mayon ash was hardly harmful to soybean.

3. To improve the nutritive value of the Lipa clay loam deficient in nitrogen, Mayon Volcano ash should not be used, for, when liberally added to the soil, it proved decidedly harmful to young radish and corn plants.

4. Moderate applications of volcanic ash to Lipa clay loam may finally bring about beneficial effects upon certain plants, such as soybean and rice.

5. Several probable causes of the harmful effects upon certain plants of the volcanic ash were considered. The two most probable causes were the production of physiologically unbalanced solutions, and compact soil, which was poorly drained and aërated.

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TABLE 1

Average heights of the different plants, in relative values

CULTURE NO.	RADISH	SOYBEAN	RICE	CORN
I	100 (15.2 cm.)	100 (34.8 cm.)	100 (55.4 cm.)	100 (59.9 cm.)
II	50	87	64	67
III	74	86	95	95
IV	82	112	95	94
V	91	99	91	92
VI	79	102	93	88
VII	143	129	141	221

TABLE 2

Average green weights of tops of the different plants

CULTURE NO.	RADISH	SOYBEAN	RICE	CORN
I	100 (13.5 gr.)	100 (38.2 gr.)	100 (6.3 gr.)	100 (20.6 gr.)
II	21	78	35	17
III	89	103	124	50
IV	56	146	127	87
V	78	98	98	71
VI	76	129	87	57
VII	363	235	588	2190

A STUDY OF THE BASE-FORMING ELEMENTS IN SOILS [1]

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The base-forming elements, calcium, magnesium, potassium, and sodium, are generally conceded to be important in soil management and in the tillage of agricultural lands. Soils containing a sufficient amount of them are not so easily susceptible to the residual effect of physiologically acid fertilizers as those having a very limited amount. An inadequate quantity of these elements in the soils is not only conducive to the formation of acid soils but also to the leaching out of plant foods.

According to Lange (1925), Ganssen finds that for neutral, absorptive-saturated fertile soils, the molecular relation of SiO_2 to Al_2O_3 to total base (CaO, MgO, K_2O, and Na_2O) is 3:1:1; for infertile, acidic, absorptive-unsaturated soils, $3:1:>1$; for infertile, alkaline, $3:1:<1$. Gehring (1929) reports that the data on the degree for saturation of potassium and magnesium are of value only when that of calcium is known. Vageler, as cited by Jacob (1932), is of a similar opinion. Jacob states further that since the different bases do not have similar effects on the soils the total base content should be considered. Bear (1931) reports that calcium and magnesium have the ability to flocculate the colloidal particles of soils, whereas potassium and sodium have the opposite effect. The soil colloids which influence not only the physical and chemical but also the biological properties of soils owe their desirable or undesirable nature to their base contents.

A study of how calcium, magnesium, potassium, and sodium exist in soils may throw light on the chemistry and mechanism involved in their replenishment of the soil solution during the whole growing season of a crop.

The main interest, therefore, of this paper is to determine the relative amounts of the different soil bases existing in soluble form readily available to plants; in the colloidal complex, the amounts which are exchangeable or displaceable; and in the soil minerals the amounts which are soluble only in strong mineral acids.

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[1] Experiment Station contribution No. 1305. Read before the Fifth Philippine Science Convention, February 24, 1939. The greater part of the experiment was performed by the writer while connected with the Department of Agricultural Chemistry.

MATERIALS AND METHODS

Nine composite soil samples of Lipa clay loam were used in the present study. They were collected from the College of Agriculture farms, Los Baños, Laguna, and prepared for analysis by the students who matriculated in Agricultural Chemistry 120 in the first semester of the academic year 1934-1935 under the supervision of the writer and Mr. F. Soliven, then of the Department of Agricultural Chemistry. According to Aquino and Mamisao (1939), this soil type is mellow and friable. The surface soil has an average depth of 30 centimeters. The subsoil, which is reddish brown, is heavier in texture than the surface soil. Sample 1 was collected in the lot between the Sugar Mill and the Biochemistry buildings; sample 2, between the Gas Plant and the star apple plantation; sample 3, between the Agricultural Botany and the Agricultural Chemistry Buildings; sample 4, in the corn field near the Poultry Building; sample 5, between the Rural High School and the Biochemistry Buildings; samples 6 and 7, in the orchards near the Guard's House and behind the College Infirmary respectively; and samples 8 and 9, in the fields of Mr. Toribio Mercado and Doctor José M. Capinpin respectively.

The base-forming elements present in the soils in soluble form were extracted in a manner similar to the method used by Alten (1933); the amounts contained in the soil complex were determined in accordance with the technique of Gehring (1929); and those in the soil minerals, by treating the soils with 10 per cent HCl as carried out by Galvez (1938).

RESULTS AND DISCUSSION

The results of the analyses, which are an average of duplicate determinations calculated from oven-dry samples, are given in tables 1a, 2a, and 3a.

In table 1a, the amounts of CaO present in the soil minerals may be seen to vary in the nine composite samples in spite of the fact that the samples were collected in a region of the same temperature and rainfall. This may also be noted in the case of MgO, K_2O, and Na_2O.

Since the subsoil serves as a very good source of soil bases, especially during the time when the rate of evaporation of water from the surface is much faster than that of the downward gravitational movement, its base contents are also determined. In table 1b, it is very apparent that the facts revealed by the data in table 1a are corroborated; that is, the different bases vary with the different samples.

The amounts of the base-forming elements contained in the soil complex (tables 2a and 2b) as well as those in the soluble forms (tables 3a and 3b) show a similar tendency, in that the amounts of CaO, MgO, K_2O, and Na_2O fluctuate from sample to sample.

The data for the subsoils, tables 1b, 2b, and 3b, are in full accord with those for the surface soils.

The figures in table 4, clearly show that the amount of CaO held in reserve exceeds that of MgO, K_2O, and Na_2O. Also MgO is higher than the value of either K_2O or Na_2O. This is likewise observed in the soil complex. In his study of the base exchange properties of certain Philippine soils, Aquino (1936) reports that the amount of replaceable calcium is higher than that of magnesium. In his study on the replaceable bases in some Philippine soils, Marfori (1930) gives similar results. Robinson (1932) reports that, in normal soils, calcium is the principal exchangeable base, while magnesium, potassium, and sodium are present in smaller amounts. This table also shows that in the soluble forms, the divalent bases, calcium and magnesium, are much more than the monovalent bases, potassium and sodium. This finding coincides with that of Burd and Martin (1924).

The subsoils support the conclusion brought out by the surface soils.

It is very evident in table 4 that the basic constituents in the soil mineral are the most while those in the soluble form are the least. This is also true of the subsoils. According to these results, the amount of soil base brought into solution at one time is only about 4 per cent of the total base content; at this rate, the solutions may be expected to contain bases up to the twenty seventh extraction.

From this study, the chemistry and mechanism involved in the replenishment of calcium, magnesium, potassium, and sodium may be explained as follows: Soils containing an adequate amount of water have their soil minerals, soil complex, and soluble forms, all of which are carriers of bases, in a state of equilibrium. The moment the soluble forms are removed from the soils, the state of equilibrium is disturbed. But on the addition of an equivalent amount of water, the soil bases are liberated from the soil minerals by the process of hydrolysis and simultaneously from the soil complex by displacement until a state of equilibrium is again restored. Van de Loo (1934) and Galvez (1934) report that the several soil solutions obtained from the same soil by repeatedly saturating the soil with distilled water and then pressing after twenty-four hours always contain calcium, magnesium, potassium, and sodium.

SUMMARY AND CONCLUSION

From the above findings, the following may be concluded:

1. The base-forming soil elements, calcium, magnesium, potassium, and sodium, exist in varying amounts in three different forms, namely, soluble, soil complex, and soil minerals.

2. The amount present in the soil minerals was the highest, and that in the soluble form, the lowest.

3. Of the four soil bases studied, calcium was the dominant base in the three forms, followed by magnesium; the monovalent potassium and sodium were the lowest.

4. The subsoil, which is a good source of soil bases during summer days, corroborated all the facts revealed by the surface soils.

5. The chemistry and mechanism concerned in the replenishment of the basic constituents in the soil solution may be attributed to the existence in the soils of a system: soil mineral$\rightleftarrows$soil complex $\rightleftarrows$soluble forms. This system is in a state of equilibrium in the presence of water. As soon as the soluble bases at one time are removed in the form of solution from the soil, the state of equilibrium is momentarily disturbed, but on addition of an equivalent amount of water it is again restored by the process of hydrolysis of the soil minerals and simultaneously by displacement in the soil complex.

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TABLE 1a

Average amounts of base-forming elements in the soil minerals

SURFACE

SAMPLE NO.	CaO	MgO	K_2O	Na_2O
	per cent	*per cent*	*per cent*	*per cent*
1	0.366	0.448	0.094	0.058
2	0.479	0.407	0.064	0.112
3	1.257	0.322	0.040	0.077
4	0.264	0.516	0.250	0.174
5	0.221	0.138	0.179	0.200
6	1.177	0.962	0.249	0.080
7	0.882	0.159	0.193	0.255
8	0.383	0.675	0.094	0.216
9	1.701	0.519	0.165	0.134

TABLE 1b

Average amounts of base-forming elements in the soil minerals

SUBSOIL

SAMPLE NO.	CaO	MgO	K_2O	Na_2O
	per cent	*per cent*	*per cent*	*per cent*
1	0.190	0.376	0.084	0.121
2	0.428	0.355	0.114	0.116
3	1.256	0.431	0.046	0.081
4	0.289	0.467	0.067	0.144
5	0.264	0.246	0.212	0.250
6	1.006	0.488	0.233	0.206
7	0.154	0.338	0.104	0.336
8	1.025	0.639	0.118	0.260
9	0.411	0.543	0.169	0.200

TABLE 2a

Average amounts of base-forming elements in the soil complex

SURFACE

SAMPLE NO.	CaO	MgO	K_2O	Na_2O
	per cent	*per cent*	*per cent*	*per cent*
1	0.468	0.085	0.009	0.027
2	0.471	0.086	0.008	0.028
3	0.484	0.084	0.000	0.030
4	0.449	0.108	0.068	0.010
5	0.518	0.132	0.058	0.030
6	0.315	0.099	0.060	0.037
7	0.450	0.128	0.065	0.017
8	0.545	0.142	0.133	0.041
9	0.545	0.110	0.122	0.056

TABLE 2b

Average amounts of base-forming elements in the soil complex

SUBSOIL

SAMPLE NO.	CaO	MgO	K_2O	Na_2O
	per cent	*per cent*	*per cent*	*per cent*
1	0.555	0.078	0.000	0.035
2	0.512	0.093	0.002	0.042
3	0.540	0.100	0.000	0.033
4	0.662	0.133	0.083	0.030
5	0.655	0.122	0.085	0.030
6	0.350	0.081	0.058	0.019
7	0.480	0.126	0.065	0.023
8	0.575	0.139	0.049	0.030
9	0.530	0.100	0.090	0.040

TABLE 3a

Average amounts of base-forming elements in the soluble forms

SURFACE

SAMPLE NO.	CaO	MgO	K_2O	Na_2O
	per cent	*per cent*	*per cent*	*per cent*
1	0.010	0.010	0.005	0.004
2	0.009	0.014	0.003	0.008
3	0.007	0.012	0.002	0.004
4	0.047	0.018	0.002	0.026
5	0.071	0.023	0.003	0.020
6	0.058	0.022	0.001	0.030
7	0.068	0.030	0.002	0.018
8	0.072	0.019	0.003	0.023
9	0.054	0.021	0.003	0.040

TABLE 3b

Average amount of base-farming elements in the soluble forms

SUBSOIL

SAMPLE NO.	CaO	MgO	K_2O	Na_2O
	per cent	*per cent*	*per cent*	*per cent*
1	0.020	0.017	0.007	0.007
2	0.019	0.016	0.008	0.013
3	0.013	0.017	0.003	0.004
4	0.049	0.020	0.000	0.026
5	0.061	0.019	0.002	0.020
6	0.044	0.013	0.000	0.025
7	0.066	0.026	0.001	0.011
8	0.050	0.013	0.003	0.020
9	0.059	0.020	0.001	0.031

TABLE 4

Comparison of the base-forming elements present in the different forms in soils

	CaO	MgO	K_2O	Na_2O
	per cent	*per cent*	*per cent*	*per cent*
SURFACE				
In soil minerals	0.747	0.461	0.166	0.145
In soil complex	0.472	0.108	0.058	0.031
In soluble forms	0.044	0.019	0.003	0.019
SUBSOIL				
In soil minerals	0.558	0.431	0.177	0.190
In soil complex	0.540	0.108	0.048	0.031
In soluble forms	0.042	0.018	0.003	0.017

DUCKS IN BATTERY LAYING CAGES [1]

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Although the use of the battery cage for laying hens has become very general in the United States and in England during the last few years, there is no report available regarding its use for laying ducks. It is very probable that the present trial may be the first attempt to use this modern innovation for ducks either in this country or abroad.

The profitable results of a recent study (Fronda and Mencias, 1937) wherein it was once more demonstrated that it is not necessary to be located near a large body of fresh water to raise ducks for profit furnished an incentive to try raising them in battery laying cages.

The laying batteries. Two separate units of laying batteries, one with a capacity of twelve birds and the other, forty-eight, were used in this study. The batteries were in three tiers and each compartment measured approximately 40 centimeters square. A mash hopper was available for each layer and a watering cup for every two.

The birds used. Sixty unselected young ducks in three different lots were used in this study. The "trial group", lot I, was placed in the battery cages on August 11, 1936. This consisted of ten ducks that were about four months old. The ducks were placed in the cages sufficiently early to get them used to confinement before they laid their first eggs. The results obtained after about seven months of this trial observation were so satisfactory that it was decided to try two more lots as the ducks became available. Thus, the second lot which consisted of thirty-two young ducks was placed in the batteries on February 16, 1937. The third lot consisting of eighteen ducks was caged on March 1, 1937.

The ration used. The ration used in these observations was essentially the same as the one reported by Fronda and Mencias (1937) to be the best for egg production in ducks. This ration consisted of 52.5 parts, by weight, of rice bran, 17.5 parts of corn meal and 30.0 parts of fish meal. The ration was supplemented with the following:

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[1] Experiment Station contribution No. 1306. Read before the Fifth Philippine Science Convention, February 21 to 26, 1939.

Cod liver oil	4 per cent
Common table salt	1 " "
Ground shells	3 " "
Green grass	daily, morning and afternoon

The feed was given wet four times a day, twice in the morning and twice in the afternoon. Each feeding time they were given as much feed as they were able to consume in about twenty minutes. Before the first feed in the morning was given, the feeding troughs were cleaned to avoid the possibility of the ducks eating sour feed.

Egg production. Individual records of egg production were kept. These records included the number of eggs produced during the first three hundred sixty-five days from the laying of the first egg. A complete record of the egg production of all the ducks used in the test is given in table 1. A summary of the records of the three lots is given in the following table:

LOT NO.	NUMBER OF BIRDS	EGG PRODUCTION		
		Per cent	Number	Range
I	10	62.3	227.5	139-314
II	32	55.3	201.8	113-311
III	18	64.7	236.1	110-320

These figures indicate that the ducks produced eggs regularly in battery laying cages. From the monthly egg records of each of these three lots, it was seen that, except in two cases, the monthly egg production of each lot did not fall below 25.0 per cent. In lot I, for instance, the egg production ranged from 38.4 per cent in October, the first month of laying, to 86.1 per cent in March. In lot II, the lowest production was recorded during November when only 14.3 per cent was obtained. At this time, the ducks were in full molt. In this lot, the highest egg production recorded was 81.5 per cent in July. The production of lot III was better than either of the first two lots, but the minimum monthly egg production of this lot was only 13.1 per cent. This was observed in November when the birds were also in full molt. The highest monthly egg record of this lot, however, was 89.6 per cent, and this was made in September. In all of the three lots observed, the highest monthly egg production was made either in the fifth or the sixth month after the birds started to lay.

With the three lots taken as a unit, and the individual production distributed into classes of 50 eggs, it was found that, of the 60 ducks under observation, 9 laid from 101 to 150 eggs each during the year; 13, from 151 to 200 eggs; 20, from 201 to 250 eggs; 15, from 251 to 300 eggs; and 3 laid from 301 to 350 eggs. The individual records of egg production of the three lots studied show that the lowest record was 113 eggs and the highest was 320. Three ducks laid over 300 eggs each a year, one from each lot. The average production of all the 60 ducks placed in the batteries was observed to be 221.8 eggs. Considering the fact that these ducks had been in the batteries for one whole year, it may be stated that this record of egg production is thoroughly satisfactory.

Incidentally, attention may be called to the egg records of the three outstanding ducks that laid over 300 eggs each during the year. In 365 days, bird No. 210 of lot I laid 314 eggs; No. 1332 of lot II, 311 eggs; and No. 4066 of lot III, 320 eggs. It is probable that these are the only known records of over 300 eggs in the Philippines, either among chickens or ducks. These accomplishments are being mentioned here for purposes of record. Two other birds, No. 156 of lot II and No. 356 of lot III, laid 293 eggs each during the year. These individual egg records show that much can be expected from the Philippine duck as an egg producer.

Feed consumption. Although records of the individual feed consumption were not kept, it was observed that each duck consumed an average of 1.08 kilograms of feed a week or a total of 56.2 kilograms of feed a year. This amount is a little higher than those previously reported (Cruz, 1932; Fronda and Mencias, 1937; and Fronda, Mencias, and Basio, 1938). It is probable that the higher record of egg production of the ducks in the present study caused the consumption of more feed. For the entire 60 ducks, the total amount of feed consumed in one year was 3,372 kilograms. The cost of this ration was ₱0.074 a kilogram which is slightly higher than that used by Fronda and Mencias (1937) on account of the cod-liver oil added to the present ration.

Cost of egg production. During the year, lot I produced a total of 2,275 eggs; lot II, 6,458; and lot III, 4,143. The three lots, therefore, laid a total of 12,876 eggs during the year. To produce these eggs, a total of 3,372 kilograms of feed was consumed. It can be seen, therefore, that 3.1 kilograms of feed were needed to produce one dozen eggs in the battery laying cages. Fronda and Mencias

(1937) reported that ducks given a similar ration but kept in outdoor laying pens needed 3.6 kilograms of feed to produce a dozen eggs. These figures indicate that eggs can be more economically produced in battery laying cages than in pens.

Length of maturity. An excellent opportunity was offered in this study to observe the age at which Philippine ducks begin to lay eggs, or the age of maturity. Local duck raisers claim that these ducks begin to lay at the age of about five and one-half months, but they also claim that they can be forced to lay eggs in about four and one-half months from hatching by the aid of artificial illumination and additional feeding at night during the brooding period. Maturity figures for individual ducks are, however, not available.

Of the ducks used in this study, the 32 individuals in lot II were hatched on September 17, 1936, and the 18 in lot III on October 17, 1936. The first egg in lot II was laid 151 days after hatching, and two ducks in this lot laid their first eggs at the age of 232 days. On the other hand, one duck in lot III laid at the age of only 141 days, and five laid between 150 and 160 days. The duck that matured the latest in this lot laid her first egg at the age of only 207 days. The mean length of maturity of all the 50 ducks in lots II and III was observed to be 181.5 days.

Mortality. Of the 60 ducks kept in the battery laying cages during the year, only 3, or 5.0 per cent of the flock, died. One of these died of leg weakness and the others died of broken egg in the oviduct. All of the other ducks were apparently healthy and vigorous. Fronda and Mencias (1937) reported a mortality of 23.7 per cent in a pen of ducks that were given a similar ration. These results tend to show that Philippine ducks can stand confinement in battery laying cages very well.

SUMMARY

The results obtained in this study show that:

1. Ducks produce eggs regularly in battery laying cages.

2. The average egg production of each lot in 365 days was as follows: lot I, 227.5 eggs; lot II, 201.8 eggs; and lot III, 236.1 eggs.

3. The highest individual 365 day-egg record in lot I was 314 eggs; in lot II, 311 eggs; and in lot III, 320 eggs.

4. Each duck in the battery consumed on the average 56.2 kilograms of feed in one year.

5. It needed 3.1 kilograms of feed to produce one dozen eggs.

6. Philippine ducks were observed to mature on an average of 181.5 days, the length of maturity varying from 141 to 232 days.

7. Ducks can stand confinement in battery laying cages very well.

8. The use of battery laying cages for the raising of ducks for egg production offers bright possibilities for commercial exploitation.

LITERATURE CITED

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TABLE 1

Individual egg records of the ducks used in the three lots [a]

LOT I			LOT II			LOT III		
Duck No.	Began laying	Eggs in 365 days	Duck No.	Began laying	Eggs in 365 days	Duck No.	Began laying	Eggs in 365 days
	1936			*1937*			*1937*	
4	27-XII	155	12	25-IV	181	356	26-III	293
	1937							
8	6-I	219	13 [b]	21-III	163	360	22-III	146
	1936							
113	13-X	139	36	25-IV	125	383	19-III	258
	1936							
168	7-XII	231	37	14-III	225	387	14-IV	235
	1936							
210	29-X	314	54	8-V	150	3133	24-IV	277
276	10-XI	286	60	24-II	223	3139 [c]	3-IV	174
944	15-IX	281	61	20-III	243	3147	2-IV	270
	1937							
957	8-II	156	62	3-III	167	3148	14-V	221
	1936							
967	26-IX	257	77	1-IV	225	3177	26-IV	169
1000	10-IX	237	81	15-III	179	3178	7-IV	242
—	—	—	83	11-III	271	3183	20-III	254
—	—	—	115	17-II	227	4017	12-IV	210
—	—	—	121	17-III	135	4026	21-IV	252
—	—	—	124	15-III	258	4033	24-IV	232
—	—	—	135	5-IV	152	4048 [d]	26-III	110
—	—	—	142	8-IV	151	4057	24-III	257
—	—	—	146	7-IV	136	4066	29-IV	320
—	—	—	149	8-IV	193	4073	10-V	223
—	—	—	153	28-III	198	—	—	—
—	—	—	154	17-II	214	—	—	—
—	—	—	155	18-III	277	—	—	—
—	—	—	156	16-II	293	—	—	—
—	—	—	336	3-III	223	—	—	—
—	—	—	341	24-II	188	—	—	—
—	—	—	1325	30-III	204	—	—	—
—	—	—	1326	25-III	252	—	—	—
—	—	—	1327	30-III	134	—	—	—
—	—	—	1328	4-IV	222	—	—	—
—	—	—	1329	22-III	209	—	—	—
—	—	—	1330	30-III	216	—	—	—
—	—	—	1331	2-IV	113	—	—	—
—	—	—	1332	22-III	311	—	—	—

[a] The ducks were placed in the cages on the following dates:
Lot I—August 11, 1936
Lot II—February 16, 1937
Lot III—March 1, 1937.

[b] Duck No. 13 died of leg weakness on January 11, 1938.

[c] Duck No. 3139 died of broken egg in the oviduct on March 6, 1938.

[d] Duck No. 4048 died of broken egg in the oviduct on September 10, 1937.

CONSTRUCTION AND IMPROVEMENT OF CASSAVA GRATERS IN THE COLLEGE OF AGRICULTURE[1]

TORIBIO MERCADO
Of the Department of Agronomy

WITH ONE TEXT FIGURE

The importance of using efficient tools in farming as in any other industry especially in the Philippines where modern agriculture is still in its infancy cannot be over emphasized. Undoubtedly many of the farm tools being used in the Philippines need improvement. Along this line of work, the Department of Agronomy of this College has made attempts to improve certain tools; among them, the cassava grater. The present paper is an account of the results so far obtained in the construction of such a grater.

An ordinary tin or plain galvanized iron sheet with punctured holes nailed to a piece of board has usually been used for grating cassava roots. The peeled roots are rubbed against the rough surface of the tin grater. With this kind of grater as much as four kilograms of roots can be grated in an hour. In the absence of the native hand grater, the cassava roots are crushed into small pieces with a mortar and pestle or with stone grinders.

According to Copeland (1908), the old Chinese method of extracting starch from cassava roots in the Straits Settlements was to crush them between two rollers. In Florida, U. S. A., a cassava grater run by a two-horse power engine was once used. It consisted of a revolving drum covered with a tin sheet punctured to make a grating surface. Over this a hopper was arranged, the whole device resting on a suitable frame.

According to Nichols (1920), one way of grating cassava in Jamaica is by pressing the peeled roots against a revolving wheel with a copper or tin grating surface.

As far as the writer is aware, the first cassava grater run by an engine in the Philippines was devised in the College of Agriculture by Professor Harold Cuzner in 1918. The Cuzner grater is run by a one and one-half horse power engine and is provided with an oscillating sieve which operates at the same time as the grating cylinder. The number of operations required in the extraction of starch with the Cuzner machine is much less than with a larger machine.

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[1] Experiment Station contribution No. 1307. The writer wishes to express his most sincere thanks to Dr. N. B. Mendiola for his suggestions and encouragement in making the device and in preparing this article.

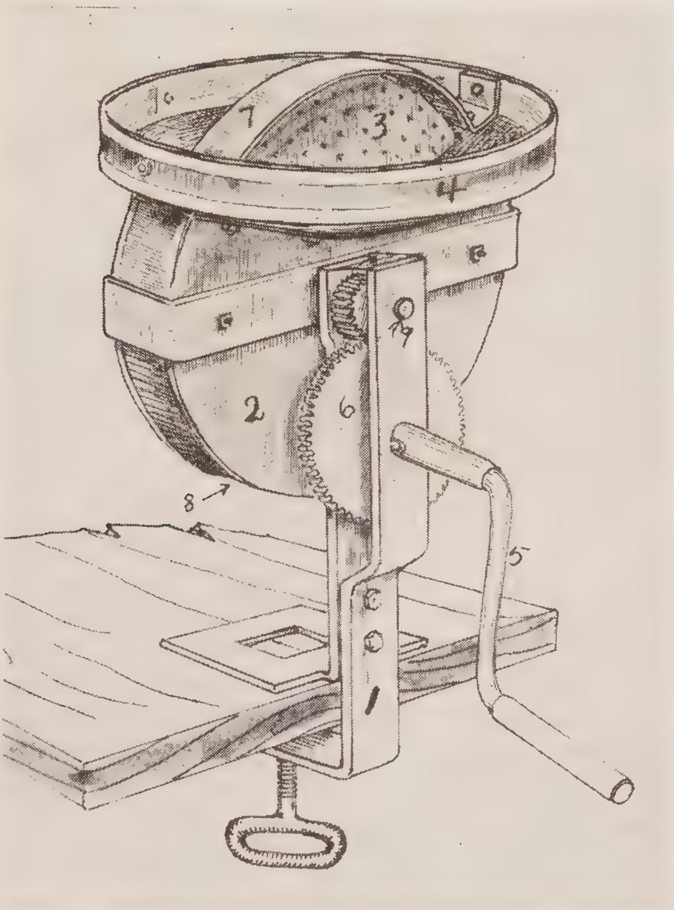

Fig. 1.—The new hand cassava grater No. 3 showing (1) stand, (2) cover, (3) blade, (4) funnel-like attachment, (5) handle, (6) gears, (7) pieces of flat iron across the funnel, (8) hole, and (9) shafts.

In 1929 Montemayor devised another grater which is now known as College grater No. 1. It is in the form of a wheel with punched surfaces on both sides. The wheel is covered with a piece of board to prevent the cassava meal from flying out. Each side of the grater is provided with a feeder. The cassava meal drops by gravity into a receptacle. It is operated like a sewing machine with the feet providing the power and the hands feeding the grater. Its grating capacity ranges from 12 to 24 kilograms of roots per hour. Costing ₱30.00, it is made of wood, iron and galvanized iron sheets.

Mendiola in 1931 devised another grater patterned after one used in Java. It is operated like a bicycle and is known as College grater No. 2.

Information furnished the writer by the Director of the Bureau of Plant Industry shows that a grater whose construction is similar to College grater No. 1 has been recommended to Filipino cassava growers. The College of Agriculture has sold this grater in different parts of the Philippines.

The work covered by this report includes mainly the observations on graters and other machines found in the College of Agriculture from 1933 to 1938.

The main object of this paper is to report a new grater which has recently been devised by the writer.

DESCRIPTION OF THE GRATER

The grater under report is illustrated in figure 1 and may be known as College grater No. 3. It is 29 centimeters high and its greatest diameter is 23 centimeters. It has five main parts, namely, (1) the stand, (2) the cover, (3) the blade, (4) the funnel-like attachment, and (5) the handle. The iron stand (1) which holds the entire machine in place can be clamped at the edge of a table. The cover (2) is 23 centimeters in diameter, 5 centimeters thick and is made of plain galvanized iron sheet. On top of the cover is a shallow funnel-like attachment (4) made of galvanized iron sheet, 23 centimeters in diameter also, and is used to hold the cassava roots being grated. Across the funnel-like attachment is a curved piece of iron (7) which may be used to break some of the big roots to be grated and at the same time to prevent the grated products from being thrown away. At the bottom of the cover is a hole (8), 13 centimeters long and 3.5 centimeters wide, through which the grated products fall. The blade or rasper (4) is a round piece of iron plate 6 millimeters thick and 22 centimeters in diameter. It is punctured on both sides like rasps or files. The blade is attached to the gears (6) by means of shafts (9). While being grated, the roots are held against both sides of the blade in the funnel-like attachment of the feeder. Water is poured little by little through the funnel to drain off the grated products completely. According to a blacksmith of the Department of Agronomy of the College, different sizes of this new grater can be made at costs ranging from ₱5.00 to ₱15.00 each.

EFFICIENCY OF THE GRATER

While this grater is in operation the blade rotates like a wheel at the middle of the cover bisecting the funnel-like attachment, thus gradually rasping or grating the roots. In this manner the starch cells are broken completely. This particular sample of the new cassava grater under report can grate as much as twelve kilograms of roots an hour; hence it is 200 per cent more efficient than the native hand graters. By increasing the ratio of the gears and the diameter of the blade, its grating capacity may be greatly increased. A device with a gear ratio of 4 to 1 (driver to driven) and with a blade, 31 centimeters in diameter could grate as much as 76 kilograms of peeled roots in one hour and would be over 200 per cent more efficient than portable graters Nos. 1 and 2. As much as 20 per cent of starch can be extracted by the use of this machine.

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MENDIOLA, N. B. 1931. Cassava growing and cassava starch manufacture. Cir. No. 21. pp. 1–30. *Fig. 1–12.*

MONTEMAYOR, Z. 1929. A promising cassava grater for the farm. The Philippine Agriculturist 17: pp. 593–597. *Fig. 1–2.*

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COLLEGE AND ALUMNI NOTES

The Board of Regents, at its meeting on May 26, confirmed the appointment of Dr. Leopoldo B. Uichanco, head of the Department of Entomology, as Dean of the College of Agriculture.

Dr. F. O. Santos, head of the Department of Agricultural Chemistry, and Dr. G. O. Ocfemia, head of the Department of Plant Pathology, were appointed by the President of the Philippines as two of the five delegates to the Sixth Pacific Science Congress to be held at the University of California and Stanford University from July 24 to August 12, 1939. They sailed on June 26. After the congress, they plan to visit important institutions of learning in the United States as well as in Europe before returning to the Philippines towards the end of October.

Mr. O. D. Hargis, Dr. Stanton Youngberg, and Dr. Robert L. Pendleton, members of a commission for Jewish refugees, were campus visitors on April 20. Dr. Pendleton was formerly head of the Department of Soils.

The first semester began on June 5 with the usual opening exercises. Dr. A. L. Teodoro, head of the Department of Agricultural Engineering, spoke on behalf of the faculty; and Mr. Valentin G. Cedillo, of the student body. Dean Uichanco gave an address of welcome to the students.

Recent additions to the faculty of the College are: Mr. I. Macaspac, assistant instructor in Plant Pathology; Mr. D. Umali, assistant instructor in Agricultural Chemistry; and Mr. L. P. Zialcita, assistant instructor in Poultry Husbandry.

STUDIES ON THE CYTOLOGY AND CROSS-COMPATIBILITY OF SOME COTTON VARIETIES [1]

J. M. Capinpin and Ian Khambanonda
Of the Department of Agronomy

WITH FOUR PLATES AND ONE DIAGRAM

The genus *Gossypium*, to which all cultivated cotton belongs, has been found to be taxonomically divided into two distinct chromosomal groups, which, from the plant breeding point of view, offer many interesting problems. Since varying degrees of success in securing fertile hybrids from cotton species within a group as well as between the two groups have been attained, it would be of interest to conduct such investigations with local and introduced cotton species and varieties grown in the Philippines for the purpose of considering the resulting crosses between distinct chromosomal groups both from an economic and a scientific viewpoint.

Review of literature

Three independent workers, Denham (1924) in England, Nikolajeva (Zaitzev,) in Russia, and Longley (1933) in the United States, reported the diploid number of the Old World or Asiatic species as 26, and that of the New World or American species as 52.

Skovsted (1934a, 1935) measured the sizes of the chromosomes and observed satellites. He then classified cotton species into three chromosomal groups: (*a*) Haploid New World species with 26 small somatic chromosomes ($2n = 26$), (*b*) Asiatic species with 26 larger somatic chromosomes ($2n = 26$), and (*c*) Diploid New World species with 52 somatic chromosomes ($2n = 52$). He emphasized that the variation in size was not the result of a genetic factor but might be due to a physico-chemical reaction and maintained that the presence of satellites was the determinant.

Mikhailova (1938) affirmed that in the New World cotton 26 larger and 26 smaller chromosomes were present, but that the distinction was not absolute. Arutjunova (1936) denied the differences in chromosome sizes and pointed out that satellites were too small to serve as a criterion in the differentiation of chromosomes.

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[1] Experiment Station contribution No. 1308.

Davie (1933) suggested 7 as the basic chromosome number of the Malvaceae to which cotton belongs.

The following species and varieties which are involved in these studies were reported to have the following chromosome counts:

(*a*) *Gossypium barbadense* Linn. var. Sea Island and Pima Egyptian .... 52 chromosomes reported by many investigators.

(*b*) *G. punctatum* Sch. et Thon. .... 52 chromosomes (Zaitzev, 1928; Baranov, 1930). var. Baroueli .... 18-22 chromosomes (Szymanek, 1932) var. Koriba .... 20-26 chromosomes (Szymanek, 1932).

(*c*) *G. obtusifolium* Roxb. .... 26 chromosomes (Zaitzev, 1928; Banerji, 1929; Barnanov, 1930; Longley, 1933).

Skovsted (1934b) stated that all the Old World cottons were interfertile, and the New World species practically so. His extensive research showed that some species of the 26 diploid chromosomes did not cross with each other.

Numerous reports were published concerning the hybridization of cottons between the two chromosomal groups. In these crosses, the percentage of success varied. At the Central Breeding Station, Russia (Anonymous, 1933), it ranged from 0.01 to 2.5 per cent; at Tashkent, Russia, it was 0.003 per cent (Vycotski, 1930). All breeders agreed that the hybrid between these two groups could be produced with difficulty. The incompatiblity was not due to the delay or failure of pollen tube to reach the ovary (Feng, 1934; Romanov, 1936) but rather to the non-union of gametes.

Generally, the hybrid seeds were produced when the 52-chromosome plants served as the female and the 26-chromosome, the male. Kanash (1932) concluded that the lower chromosome species would not be an effective maternal parent. He further stated that certain species showed a more marked tendency to parthenocarpy than others, especially the 26-chromosome species.

All cotton hybridizers found that many of the hybrid seeds formed were empty or failed to germinate. Several gave completely sterile plants. The rest produced self-sterile but partially fertile plants when used to backcross with the 52-chromosome parent. Heterosis was observed in the F_1 plants. The sterility was eliminated after the first backcrossing, (Kanash 1932, 1936; Harland 1932, 1937).

In most cases, the F_1 plants were triploids ($2n = 39$); others, tetraploids ($2n = 52$). Nakatomi (1931) attributed the sterility of the triploids to the irregular chromosome behavior in the meiosis. Feng (1934) found that the sterility was much higher when the Asiatic type was used as a female parent. After backcrossing with the 52-chromosome type, the plants were of various chromosomal types containing from about 52 up to 65 chromosomes. The commercial possibility of these backcrosses was believed to be great.

Apparently no previous study on crossing has been conducted on the wild type of cotton involved in this investigation.

Objects of the work

This work had the following objects: (*a*) to study cytologically some cotton species and varieties and their F_1 hybrids grown in the Philippines, (*b*) to undertake a general survey of compatibility between the species and the varieties.

Time and place of the work

This work was performed from October, 1937, to February, 1939, and involved two flowering and fruiting seasons of cotton. The hybridization was done in the garden of the genetics and plant breeding division and in the Experiment Station fields of the Department of Agronomy. The cytological investigation was conducted in the laboratory of the genetics and plant breeding division of the Department of Agronomy, College of Agriculture, Los Baños, Laguna.

MATERIALS AND METHODS

Cotton varieties used

Seven cotton varieties were included in this study (Plate 1), two recently introduced and five old ones.

Recently introduced varieties. (*1*) Sea Island (*Gossypium barbadense*)—plants of the cotton and tobacco division in the Experiment Station field.

(*2*) Pima Egyptian (*G. barbadense*)—plants of the cotton and tobacco division in the experiment station field.

Old Philippine varieties. (*1*) Batangas White (*G. punctatum*)—plants grown in can cultures; seeds were received by the senior author from Lamao Horticultural Station through the Director of the Bureau of Plant Industry, Manila, June 23, 1937.

(*2*) Batangas Light Brown (*G. punctatum*)—plants in can cultures; seeds were received by the senior author from the Bureau of Plant Industry, Manila, August 25, 1937.

(*3*) Batangas Dark Brown (*G. punctatum*)—plants in can cultures; seeds were received by the senior author from the Bureau of Plant Industry, Manila, August 25, 1937.

(*4*) Ilocos Brown (*G. paniculatum* Blanco)—plants in can cultures; seeds were received by the senior author from the Provincial Agronomist, Laoag, Ilocos Norte, August 16, 1937.

(*5*) Philippine wild cotton (*G. obtusifolium*)—plants in can cultures; seeds were received by the senior author from Dr. V. C. Calma, May, 1936. These cotton seeds were given to Dr. Calma by Dr. Stangl of Bacolod, Negros Occidental, who collected them from a mountain southeast of Caliling, Cauayan, a supposedly unexplored region. The seeds studied were second generation harvest from the cultures of the division of genetics and plant breeding.

Hybridization technique

Flower buds which were to open on the next day were emasculated in the afternoon from 4:00 to 6:00 o'clock. The operation consisted of the removal of the corolla and the staminal column strip by strip with a pair of small, pointed forceps. Since the flowers of the wild cotton were small, great care was exercised in the removal of the staminal column. This method was found to be almost the same as that recommended by Doak (1934). The anthers were taken out whole. The technique was found to be effective and efficient. Small, glazed paper bags were used to prevent any pollen contamination.

Pollination was performed the next day between 9:00 a. m. and 12:00 noon or sometimes as late as 1:00 p. m. on cloudy days. Repollination was found unnecessary as the stigmas had wilted by the following day. Two days after pollination, the bags were removed. The bolls were picked when they began to crack.

Flowers and bolls not used in hybridization were pinched off to decrease the effect of natural shedding and to stimulate the production of mature bolls, as suggested by Eaton (1927). The ringing method advised by Tanaka (1937) was employed in ten flowers of the cross, Pima Egyptian × Wild cotton, with the former as a female parent. No appreciable results were obtained, and the method was abandoned.

No treatment of the stigma was made because it was reported by Feng (1934) and Romanov (1936) that incompatibility was not due to the growth of the pollen tube.

In these studies, forty crosses involving introduced and native varieties as well as inter and intra-chromosomal groups of cotton were made.

Cytological technique

The technique used by Skovsted (1933) was adopted as this had been found suitable under tropical conditions.

(*a*) *Permanent preparation for root tips.* Root tips were obtained in the morning from seeds germinated in earthen seed-pans with sawdust as the medium. They were fixed in Navashin solution.

The fixative was prepared immediately before being used. After six hours of fixation, it was replaced by another fresh solution for a further eighteen-hour treatment.

Sections were cut 10 microns thick, and materials were stained with Heidenhain's iron-alum haematoxylin.

(*b*) *Smear preparation of flower buds.* Flower buds were fixed in Carnoy's fluid, preserved in alcohol, and crushed in acetocarmine or Belling's solution. This technique was employed merely to judge the correct age of flower buds showing different mitotic stages.

(*c*) *Permanent preparation of flower buds.* Flower buds were collected from 8:00 a. m. to 12:00 noon. The stage of the buds was determined by the smear method. The bud was very small at about the stage of the emergence of the corolla and before the appearance of the spiny ectoderm in the pollen mother cells.

The buds passed through the prefixative of Winge's Picro Carnoy solution for fifteen minutes, and then through the osmic acid modification of Allen's Bouin for twenty-four hours.

Sections were cut 15 microns thick, bleached in potassium chlorate solution (a few grams potassium chlorate, a few cc. nitric acid, and 150 cc. 70 per cent alcohol), and stained with Heidenhain's iron-alum haematoxylin.

In paraffin sections, hundreds of slides were prepared. Cells with clear chromosome configurations were selected for critical observations and cytological illustrations.

The cytological drawings were prepared with Bausch and Lomb camera lucida at table level by means of a Bausch and Lomb microscope with 1.9 mm. (N.A. 1.30) apochromatic oil immersion objective and 20× ocular. The approximate magnification of the drawings was 3,400.

EXPERIMENTS AND RESULTS

The results of cross-pollination between species and varieties of cotton studied are shown in table 1 and diagram 1.

The chromosome numbers of the species, varieties, and their F_1 hybrids are presented in table 2 and plates 3 and 4.

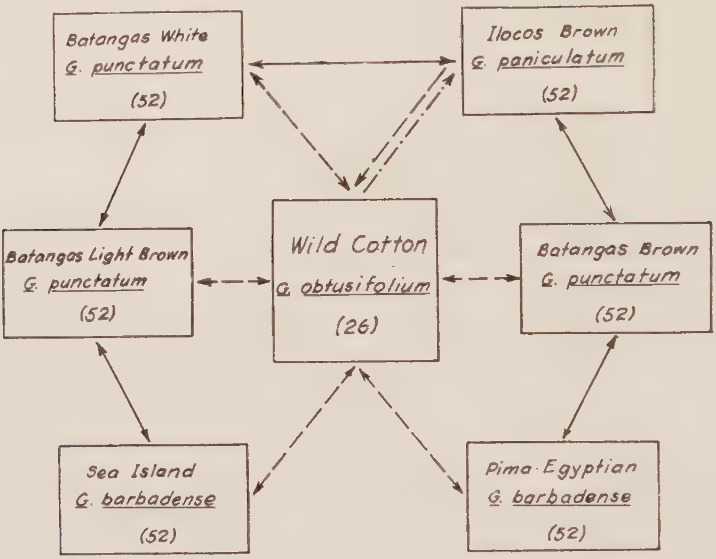
Batangas White
G. punctatum
(52)
Ilocos Brown
G. paniculatum
(52)
Batangas Light Brown
G. punctatum
(52)
Wild Cotton
G. obtusifolium
(26)
Batangas Brown
G. punctatum
(52)
Sea Island
G. barbadense
(52)
Pima-Egyptian
G. barbadense
(52)

Diagram 1.—Showing results of cross pollinations between species and varieties of cotton studied.

———— compatible crosses

- - - - - incompatible crosses

-·-·-·- non-viable seed produced from the cross.

DISCUSSION OF RESULTS

Interspecific and varietal crosses

In the hybridization, the two introduced varieties, Sea Island and Pima Egyptian, were not crossed together. These representatives of *G. barbadense* were crossed with the three species of Philippine cotton, namely, *G. punctatum* represented by Batangas cotton varieties, *G. paniculatum*. by Ilocos Brown, and the newly discovered wild type of cotton, herein provisionally called *G. obtusifolium*. This scientific name was adopted after the key of Watt (1907) had been consulted and the statement of Merrill (1923) checked.

All crosses, except those with the wild species, were compatible.

Of the hybrids, with the wild cotton as the male parent, all bolls dropped off within fifteen days.

In the reciprocal crosses where the wild species was the female parent, there was a marked tendency towards parthenocarpy. Bolls developed normally, but most of them fell off within three weeks, the rest, within four weeks (plate 2, fig. 3). All seeds were immature and failed to germinate.

In the cross between wild cotton and Ilocos Brown, one boll stayed longest on the plant. It dried after forty-four days and dropped off in the next five days (Plate 2 fig. 2). One mature seed among many shrivelled ones was collected, but it failed to germinate.

The positive and negative results obtained in the cross-pollinations between species and varieties studied are indicated in diagram 1.

It is evident from the results herein presented that *G. barbadense, G. punctatum,* and *G. paniculatum* were cross-compatible and may be considered interfertile. The Philippine wild type, *G. obtusifolium,* proved to be cross-incompatible with *G. barbadense* (Sea Island and Pima Egyptian) and *G. punctatum* (Batangas cotton varieties) and practically so with *G. paniculatum* (Ilocos Brown). In the latter species, out of twenty flowers, one boll which produced one seed was formed. The crossed seed, however, was non-viable. The fact that a mature boll was formed in this pollination leads to the possibility that a positive cross might in the future be obtained.

The chromosomal groups of the cotton varieties

In table 2, it will be noticed that the cotton species and varieties studied fall under two distinct groups, namely, the 52 and 26 chromosomal groups. *G. barbadense,* represented by Pima Egyptian and Sea Island, contains 52 chromosomes (2n). *G. punctatum,* represented by Batangas White, Batangas Light Brown, and Batangas Dark Brown, and *G. paniculatum,* represented, by Ilocos Brown, showed 52 chromosomes in diploid phase. These chromosome counts of the Philippine native commercial cotton varieties put them into the same category as the New World or American cotton and lead to the belief that they must have been introduced. The wild type, *G. obtusifolium,* contains 26 somatic chromosomes and forms a distinct chromosomal group. This chromosome determination con-firms the reports of Zaitzev (1928), Banerji (1929), Baranov (1930), and Longley (1933), who found 13 haploid chromosomes in this same species (*G. obtusifolium*) and puts this species into the Old World or Asiatic cotton group. While no critical study on chromosome morphology of this species was made, the wild species herein reported revealed such size of chromosome which fall under the 26 large chromosome group of Skovsted (1935).

According to these studies, the two long-staple and the four short-staple varieties of the cultivated group are of 52-chromosome kind, whereas the wild type of the short-staple belongs to the 26-chromosome group. It is interesting to report that crosses between species and varieties within the 52-chromosome group proved to be interfertile, whereas those between varieties and species of different chromosome numbers proved to be incompatible. The latter phenomenon appears to be a confirmation of the belief that "species of *Gossypium* from the New World and Australia (with n = 13) are more easily crossed with New World cottons (n = 26) than the species from the Old World (n = 13)." According to this statement, the *G. obtusifolium* here studied belongs to the Old World cotton (n = 13) which, numerous reports and present investigations indicate, crossed with difficulty with New World cottons (n = 26).

Somatic mitosis and meiosis of cotton species studied

The somatic chromosomes of the 52-chromosome cotton varieties (plates 3 and 4) appear not to differ markedly in shape. All these figures were obtained in the root tips. The chromosomes of the wild type were apparently of the larger group as classified by Skovsted (1935), who attempted to differentiate this group into 26 small and 26 large chromosome types. Examinations of the microscopic slides reveal that the size of the 52-chromosomes and the 26-chromosomes was apparently the same. When one looks at a somatic plate containing 52 chromosomes, however, and at another containing 26 chromosomes, the latter appear slightly larger because of the fewer number.

The meiotic stages of the cotton were obtained from the pollen mother cells. In these studies, only those microscopic preparations which showed clear chromosome configurations were considered.

In the 52-chromosome cotton, shown by Pima Egyptian (plate 4, fig. 3), the chromosomes in the first division metaphase form in regular alignment of 26 bivalents. Other stages following this phase have shown regular disjunction where 26 chromosomes form at the two ends of the late anaphase. From these observations, it would seem that the division was equal, 26 chromosomes being found in the pollen gamete. The absence of lagging chromosomes strengthens the belief that there was regular disjunction. Since no change in chromosome number was discovered in the F_1 hybrids, no critical studies on reduction phase were made.

In the 26-chromosome type, as shown by the wild cotton (plate 4, fig. 2), the formation of 13 bivalents in heterotypic metaphase was easily inferred. Here again the reduction was apparently normal.

SUMMARY AND CONCLUSIONS

1. The following cotton species and varieties contained 52 chromosomes in diploid phase: *Gossypium barbadense* Linn. (Sea Island, and Pima Egyptian); *Gossypium punctatum* Sch. et Thon. (Batangas varieties); *Gossypium paniculatum* Blanco (Ilocos Brown); whereas the wild type of cotton, *Gossypium obtusifolium* Roxb. contained 26 chromosomes. These findings are in agreement with those of recent studies of the chromosome number of *Gossypium* made by investigators in various parts of the world—findings which indicate the existence of two distinct groups; namely, the Old World or the Asiatic group, in which the haploid chromosome number is 13, and the New World or the American group, in which the haploid number is 26.

2. The cultivated old commercial cotton varieties, Batangas and Ilocos, belong to the 52-chromosome group, whereas the wild cotton belongs to the 26-chromosome group.

3. Hybridization between species and varieties within the 52-chromosome group resulted in fertile crosses, whereas crosses between any of the 52-chromosome cotton and the wild type of the 26-chromosome species were all incompatible.

4. All F_1 hybrids between any two of the 52-chromosome cotton varieties showed 52 chromosomes in somatic tissues. No chromosomal aberrants appeared in the several crosses made.

5. Disjunction of chromosomes in the two chromosomal groups seemed to be regular; that is, the 52-chromosome group gave rise to gametes containing 26 chromosomes, whereas the 26-chromosome type formed gametes containing 13 chromosomes.

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TABLE 1

Results of cotton hybridization involving introduced and native varieties

PARENTAL VARIETIES	NUMBER OF FLOWERS POLLINATED	NUMBER OF MATURE BOLLS COLLECTED	TOTAL NUMBER OF SOUND SEEDS	REMARKS
Sea Island (*Gossypium barbadense*)				
Sea Island × Batangas White	43	3	37	Compatible
Sea Island × Batangas Light Brown	26	3	40	”
Sea Island × Batangas Dark Brown	25	4	55	”
Sea Island × Ilocos Brown	33	4	48	”
Sea Island × Wild cotton	33	0	0	Incompatible
Pima Egyptian (*G. barbadense*)				
Pima Egyptian × Batangas White	45	5	57	Compatible
Pima Egyptian × Batangas Light Brown	57	11	130	”
Pima Egyptian × Batangas Dark Brown	72	14	154	”
Pima Egyptian × Ilocos Brown	28	14	145	”
Pima Egyptian × Wild cotton	103	0	0	Incompatible
Batangas White (*G. punctatum*)				
Batangas White × Sea Island	9	4	22	Compatible
Batangas White × Pima Egyptian	11	2	34	”
Batangas White × Batangas Light Brown	9	3	32	”
Batangas White × Batangas Dark Brown	11	2	12	”
Batangas White × Ilocos Brown	9	1	20	”
Batangas White × Wild cotton	8	0	0	Incompatible
Batangas Light Brown (*G. punctatum*)				
Batangas Light Brown × Sea Island	12	5	97	Compatible
Batangas Light Brown × Pima Egyptian	28	7	124	”
Batangas Light Brown × Batangas White	12	3	23	”
Batangas Light Brown × Batangas Dark Brown	16	4	95	”
Batangas Light Brown × Ilocos Brown	14	4	70	”
Batangas Light Brown × Wild cotton	19	0	0	Incompatible

TABLE 1 Continued

PARENTAL VARIETIES	NUMBER OF FLOWERS POLLINATED	NUMBER OF MATURE BOLLS COLLECTED	TOTAL NUMBER OF SOUND SEEDS	REMARKS
Batangas Dark Brown (*G. punctatum*)				
Batangas Dark Brown × Sea Island	15	2	20	Compatible
Batangas Dark Brown × Pima Egyptian	17	3	53	”
Batangas Dark Brown × Batangas White	12	2	36	”
Batangas Dark Brown × Batangas Light Brown	14	4	67	”
Batangas Dark Brown × Ilocos Brown	17	4	66	”
Batangas Dark Brown × Wild cotton	16	0	0	Incompatible
Ilocos Brown (*G. paniculatum*)				
Ilocos Brown × Sea Island	17	3	16	Compatible
Ilocos Brown × Pima Egyptian	33	5	68	”
Ilocos Brown × Batangas White	9	4	37	”
Ilocos Brown × Batangas Light Brown	19	4	50	”
Ilocos Brown × Batangas Dark Brown	23	8	136	”
Ilocos Brown × Wild cotton	19	0	0	Incompatible
Philippine Wild Cotton (*G. obtusifolium*)				
Wild cotton × Sea Island	26	0	0	Incompatible
Wild cotton × Pima Egyptian	24	0	0	”
Wild cotton × Batangas White	20	0	0	”
Wild cotton × Batangas Light Brown	28	0	0	”
Wild cotton × Batangas Dark Brown	22	0	0	”
Wild cotton × Ilocos Brown	20	1	1	Seed failed to germinate

TABLE 2

Chromosome counts on parental types and their F_1 hybrids of cotton involving introduced and native varieties

PARENTAL VARIETIES	CHROMOSOME NUMBER	
	2n	n
Sea Island (*Gossypium barbadense*)	52	—
Sea Island × Batangas White	52	—
Sea Island × Batangas Light Brown	52	—
Sea Island × Batangas Dark Brown	52	—
Sea Island × Ilocos Brown	52	—
Pima Egyptian (*G. barbadense*)	52	26
Pima Egyptian × Batangas White	52	—
Pima Egyptian × Batangas Light Brown	52	—
Pima Egyptian × Batangas Dark Brown	52	—
Pima Egyptian × Ilocos Brown	52	—
Batangas White (*G. punctatum*)	52	—
Batangas White × Sea Island	52	—
Batangas White × Pima Egyptian	52	—
Batangas White × Batangas Light Brown	52	—
Batangas White × Batangas Dark Brown	52	—
Batangas White × Ilocos Brown	52	—
Batangas Light Brown (*G. punctatum*)	52	—
Batangas Light Brown × Sea Island	52	—
Batangas Light Brown × Pima Egyptian	52	—
Batangas Light Brown × Batangas White	52	—
Batangas Light Brown × Batangas Dark Brown	52	—
Batangas Light Brown × Ilocos Brown	52	—
Batangas Dark Brown (*G. punctatum*)	52	26
Batangas Dark Brown × Sea Island	52	—
Batangas Dark Brown × Pima Egyptian	52	—
Batangas Dark Brown × Batangas White	52	—
Batangas Dark Brown × Batangas Light Brown	52	—
Batangas Dark Brown × Ilocos Brown	52	—
Ilocos Brown (*G. paniculatum*)	52	—
Ilocos Brown × Sea Island	52	—
Ilocos Brown × Pima Egyptian	52	—
Ilocos Brown × Batangas White	52	—
Ilocos Brown × Batangas Light Brown	52	—
Ilocos Brown × Batangas Dark Brown	52	—
Philippine Wild cotton (*G. obtusifolium*)	26	13

EXPLANATION OF PLATES

PLATE 1: Seven cotton varieties under study, showing flowers, petals, mature bolls, and lint.

Fig. 1. Sea Island (*Gossypium barbadense* Linn.)
2. Pima Egyptian (*Gossypium barbadense* Linn.)
3. Batangas White (*Gossypium punctatum* Sch. et Thon.)
4. Batangas Light Brown (*Gossypium punctatum* Sch. et Thon.)
5. Batangas Dark Brown (*Gossypium punctatum* Sch. et Thon.)
6. Ilocos Brown, Kuite (*Gossypium paniculatum* Blanco)
7. Wild cotton (*Gossypium obtusifolium* Roxb.)

PLATE 2: Results of cross pollination using the wild cotton (*Gossypium obtusifolium* Roxb.) as a female.

Fig. 1. Normal mature boll (selfed) cracked open after about 60 days.
2. Boll from the cross, wild cotton × Ilocos Brown, dried after 44 days, and dropped off in 49 days; one mature but non-viable seed was obtained.
3. Boll from the cross, wild cotton × Batangas White, dropped off in 27 days. All seeds were immature.

PLATE 3: Somatic chromosomes of Batangas Dark Brown and Ilocos Brown varieties and their F_1 hybrids (×3400). Reduced to half-size in reproduction.

Fig. 1. Batangas Dark Brown × Ilocos Brown, 52 chromosomes.
2. Batangas Dark Brown, 52 chromosomes.
3. Batangas Dark Brown × Batangas Light Brown, 52 chromosomes.
4. Batangas Dark Brown × Pima Egyptian, 52 chromosomes.
5. Batangas Dark Brown × Sea Island, 52 chromosomes.
6. Batangas Dark Brown × Batangas White, 52 chromosomes.
7. Ilocos Brown × Batangas White, 52 chromosomes.
8. Ilocos Brown, 52 chromosomes.
9. Ilocos Brown × Batangas Dark Brown, 52 chromosomes.
10. Ilocos Brown × Batangas Light Brown, 52 chromosomes.
11. Ilocos Brown × Pima Egyptian, 52 chromosomes.
12. Ilocos Brown × Sea Island, 52 chromosomes.

PLATE 4:

Reproduced at approximately the same as original magnification of 3400 diameters.

Fig. 1. Somatic chromosomes of wild cotton, $2n = 26$, from root tips.
2. Heterotypic metaphase plate showing 13 bivalents in pollen mother cell of the wild cotton ($n = 13$).
3. Metaphasic stage of a pollen mother cell of Pima Egyptian variety ($n = 26$).
4. A normal tetrad from a flower bud of Batangas Dark Brown.

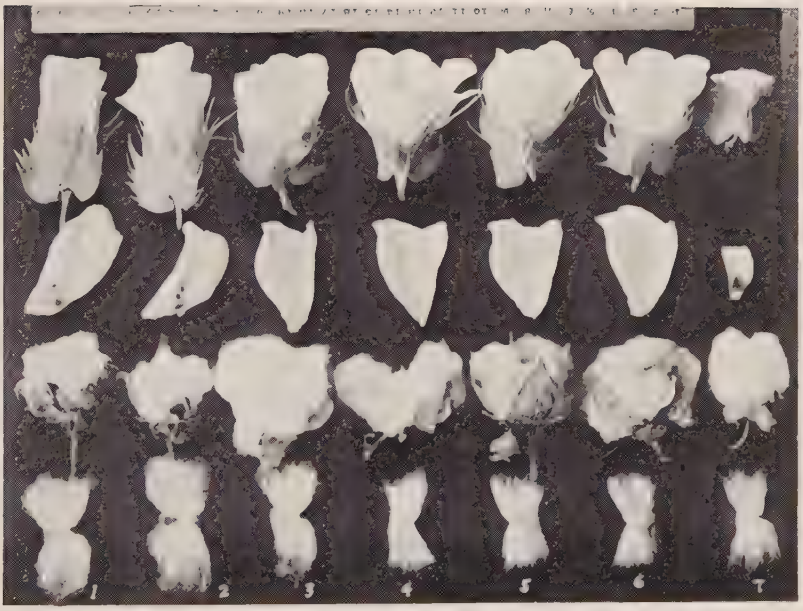

PLATE 1

PLATE 2

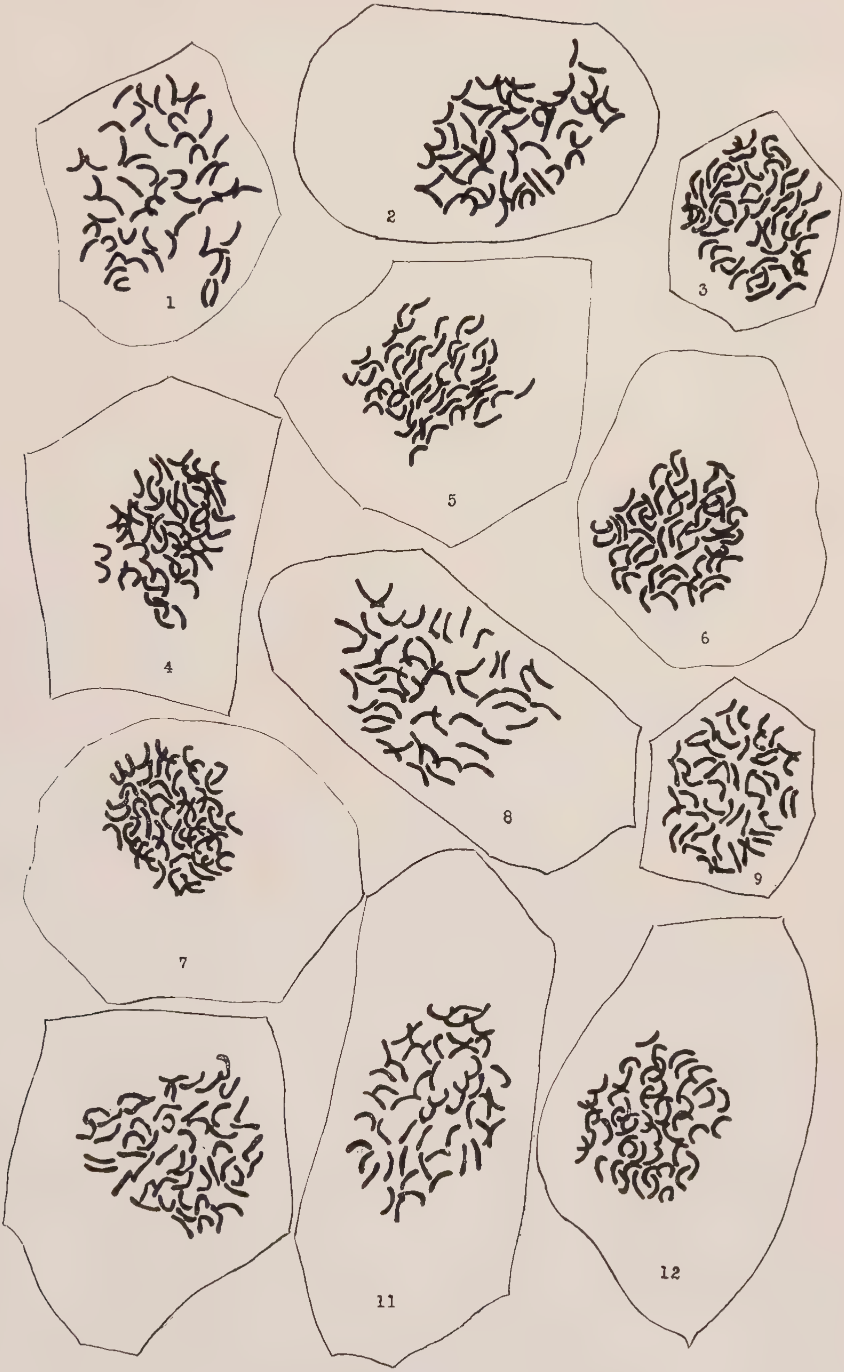
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PLATE 3

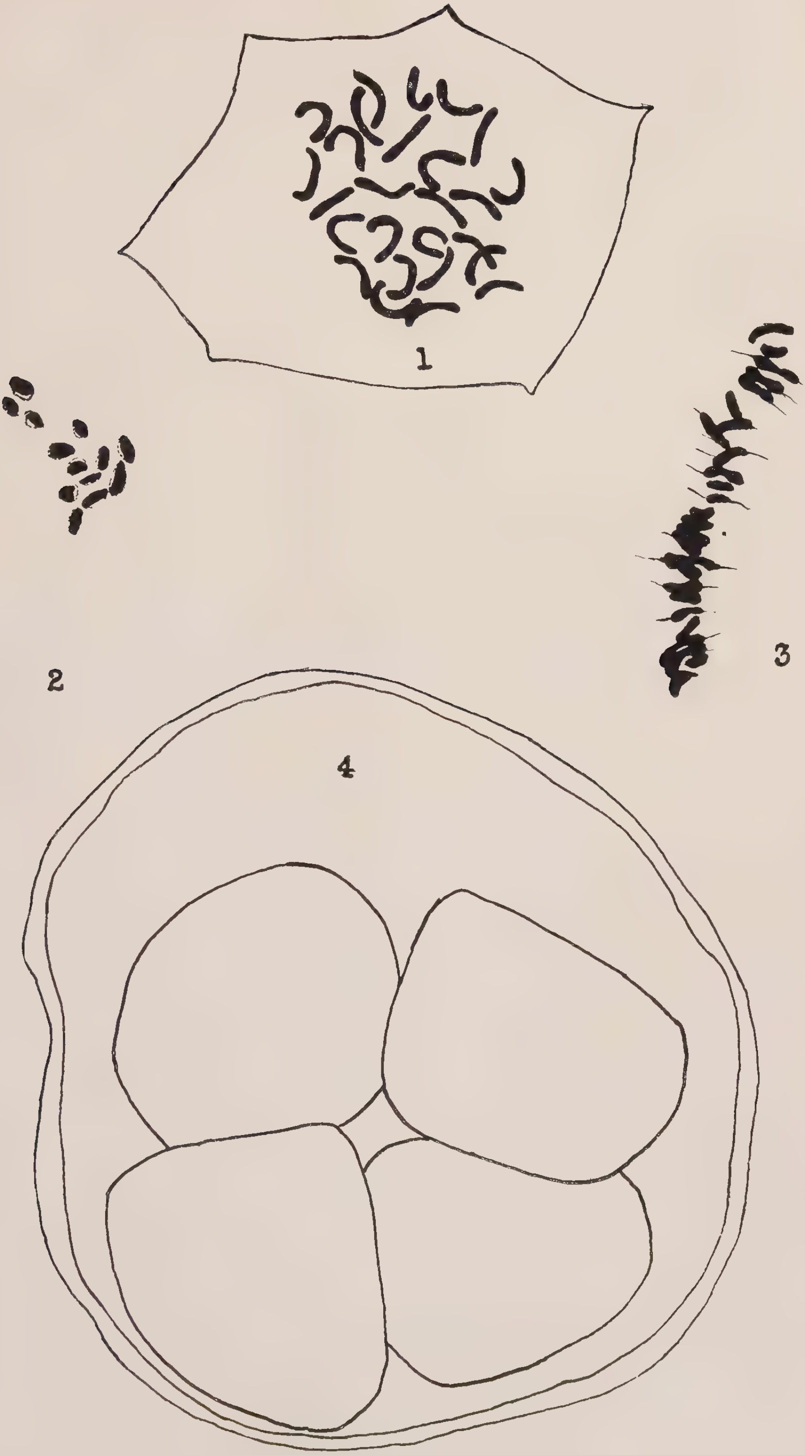

PLATE 4

HEMATOLOGICAL STUDIES ON CATTLE: III. FLUCTUATIONS IN THE HEMOGLOBIN OF INDIAN NELLORE OXEN AS AFFECTED BY SEASONAL VARIATION[1]

Miguel Manresa and Prudencio R. Falcon

WITH FOUR CHARTS

Studies on the hemoglobin of the blood of the Indian Nellore ox carried out in the College of Agriculture indicate that the hemoglobin indices follow a regular curve during the day, being somewhat high in the evening, at night, and early in the morning; and invariably low at noon and in the afternoon. These studies, however, were carried out during the summer months only and were of short duration, that is, for periods not exceeding seven days. It seemed important, therefore, to follow these studies for considerably longer periods, perhaps not less than one year, in order to determine whether fluctuations in the hemoglobin indices are influenced by seasonal variations.

Review of literature

According to the findings of Brooks and Hughes (1932), the individuality of the animal seems to be the most important factor in causing variations from the normal hemoglobin content of the blood. They state that such factors as breed, age, and prolonged fasting do not seem to affect appreciably the hemoglobin content of the blood, and that no significant variation is observed from day to day.

Burnett (1917) stated that "the blood may be considered as tissue composed of cellular and intercellular substances"; the fluid portion is considered by him as the intercellular substances. He further stated that the blood is a peculiar tissue in that it is in intimate relation with practically all the other tissues of the body, bringing substances to them and carrying away other substances.

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[1] The greater part of the data in this paper was in a thesis presented by the junior author for graduation in October, 1938, with the degree of Bachelor of Science in Agriculture, No. 1182; Experiment Station contribution No. 1309. The thesis was prepared under the direction of the senior author.

Manresa and Reyes (1934) report that the amount of hemoglobin per 100 ml. of blood in Nellore cattle is 9.87 ± 0.09 grams. Manresa, Gomez, and Santos (1939), working on Nellore cattle, determined the variation of hemoglobin during the course of twenty-four hours for a period of seven days and found the hemoglobin indices to be highest during the morning and late in the afternoon and lowest at noon. They reported the average hemoglobin to be 10.17 grams per 100 ml. of blood.

Dimock and Thompson (1906) obtained the following percentages of the several varieties of leucocytes in the blood of normal cattle; lymphocytes 54.20, large mononuclears 1.40, polymorphonuclears 30.50, eosinophiles 13.15, and mast cells 0.59. Burnett (1917) stated that a very great variation in the numbers of the several varieties has been found by Dimock and Thompson in apparently normal cattle.

Zialcita (1938) reported the percentages of the several varieties of leucocytes in the blood of Indian Nellore bull as follows: lymphocytes 50.26, large mononuclears 4.45, polymorphonuclears 31.40, eosinophiles 13.04, and mast cells 0.85.

Objects of the work

The objects of the present experiment were: (*a*) To determine the hemoglobin indices in adult Indian Nellore cattle throughout the entire year, (*b*) to find out if the fluctuations follow a regular curve in the different months of the year, and (*c*) to determine whether these fluctuations are affected by such external factors as relative humidity and atmospheric temperature, and also by internal factors such as body temperature and certain relationships with different kinds of white blood corpuscles.

Time and place of the work

This work was begun on December 20, 1936, and ended on January 2, 1938, covering a period of over one year. It was conducted in the Department of Animal Husbandry, College of Agriculture, Los Baños, Laguna.

MATERIALS AND METHODS

Animals used

Six mature Indian Nellore cattle, three males and three females, were used in this experiment. The male animals were uncastrated. The animals were treated alike as to feed, care, and management throughout the whole period of experimentation and placed under similar conditions. A complete list of the animals used in this experiment is given herewith:

NAME OF ANIMAL	HERD NO.	SEX	AGE		WEIGHT AT THE BEGINNING OF THE EXPERIMENT
			Years	Months	kilogram
Nestor	46	male	7	11	520.0
Madras Last ..	68	”	3	11	392.1
Acelo	242	”	4	1	374.6
Rosal	35	female	11	11	407.3
Rani	41	”	9	8	328.9
Daisy	52	”	7	3	390.1

Technique used in sampling the blood

Hemoglobin. A small area on the dorsal side of the pinna of the ear was cleaned and the hair cut short. After the usual antiseptic precautions were taken, the marginal vein of the ear was punctured with a lancet. The blood samples were collected after a few drops of the blood had fallen. The hemoglobin indices were determined by the improved method of Newcomer (1919) for determining hemoglobin. The samples were taken in triplicate, and the average of the three was considered the value for the determination. Hemoglobin determinations were made at intervals of one week. The time of sampling was two o'clock in the afternoon.

Relative humidity and atmospheric temperature. Readings on the relative humidity and atmospheric temperature of the air during each operation were obtained from the Department of Agricultural Botany.

Condition of the animals and their body temperatures. The live weight of the animals was recorded every thirty days, special emphasis being laid on the health of the animals. In taking the body temperature, a veterinary "S. L. Standard" thermometer was used. In no case was the thermometer held in the rectum for less than three minutes.

Differential white blood cell counts. Blood smears were made from the different animals and stained with Wright's stain. After the stain had dried in the air, the cells were examined with the two mm. (1/12 in.) oil immersion objective. There should be at least 300 leucocytes in the sample to obtain the relative proportion of the following varieties of blood cells: lymphocytes, large mononuclears, polymorphonuclears, eosinophiles, and mast cells. The percentage of each variety of cell is expressed in relation to the number of cells in the film.

RESULTS OF THE EXPERIMENT AND DISCUSSION

Monthly weights of animals

The monthly weights of the six animals used varied from month to month during the period of the experiment, but the variations were not always in the ascending order. This, however, is not surprising in view of the fact that the weights of mature animals are greatly influenced by seasonal changes. None of the females dropped a calf during the progress of the experiment. The males were heavier than the females. Bull No. 46 had the highest average weight, which was 524.62 kilograms; cow No. 41 had the lowest weight, 335.97 kilograms. The average live weight of all males was 472.9 kilograms whereas that of the females was 372.9 kilograms.

Hemoglobin indices

The results of the hemoglobin determinations on Indian Nellore cattle at intervals of one week during a period of one year were studied statistically for each animal and for the group. The means for each animal when separately computed for each month show that the hemoglobin in all the animals has followed a bimodal curve. For example, the averages in hemoglobin for bull No. 242 were 10.39 ± 0.082 grams per 100 ml. of blood for January, 10.34 ± 0.143 grams for February, 9.35 ± 0.068 grams for March, 9.04 ± 0.256 grams for April, 8.81 ± 0.089 grams for May, 8.86 ± 0.088 grams for June, 9.75 ± 0.105 grams for July, 8.73 ± 0.108 grams for August, 8.59 ± 0.153 grams for September, 9.27 ± 0.079 grams for October, 9.09 ± 0.082 grams for November, and 9.10 ± 0.035 grams for December. The hemoglobin in the different individuals oscillated from period to period, but within narrow limits of variability. The lowest average for the whole group was 8.85 grams per 100 ml. of blood, obtained in the month of September, and the highest average was 11.22 grams per 100 ml. of blood, in January. The average for the year was 9.79 grams per 100 ml. of blood, as may be seen in table 1. This is in close agreement with the data reported by Manresa and Reyes (1934), namely, 9.87 grams per 100 ml. of blood.

The fluctuations in the hemoglobin indices of the male and female animals used in this work are shown graphically in charts 1 and 2. In both the male and female oxen, the hemoglobin indices for the entire year show bimodal curves. The first curve is of seven months duration starting in October and ending in April with the mode in the month of January. The second curve of five months duration started in May and ended in September with the mode in July. The fall and rise in hemoglobin indices based on the modes was gradual and somewhat regular.

That the atmospheric temperature bears a close reciprocal but negative relation between hemoglobin indices of the Nellore cattle is shown in table 2. In the cooler months of the year, namely, from October to March, the average atmospheric temperature was 27.05° C. In the months generally considered as hot, namely, from May to September, the average atmospheric temperature was 27.73°C. or higher by 0.68°C. than that of the first period.

The hemoglobin determinations obtained by Manresa, Gomez, and Santos (1939) in mature Nellore cattle during a course of twenty-four hours for a period of seven days have also shown that the hemoglobin indices were higher during the morning and late in the afternoon when the atmospheric temperature is relatively low; and towards noon, when the atmospheric temperature is relatively high, the hemoglobin of the animals was low. Moreover, Zialcita (1938) found that the hemoglobin indices of a Nellore bull was 9.08 grams per 100 cc. at 9 o'clock in the morning, whereas in the afternoon, towards 2 o'clock, the average was only 8.44 grams per 100 ml.

Body temperature

The data on body temperature taken at intervals of one week for a period of one year reveal that the limits of variation from week to week are rather narrow but consistent. The average body temperature during the hotter part of the year computed for each month of the year, from March to July, was 39.01°C. while the average atmospheric temperature was 28.22°C. In the cooler months, from August to February, the average body temperature was 38.82°C. and the average atmospheric temperature was 26.87°C. These data bear out the common observation that body temperatures are slightly higher on days when the atmospheric temperatures are high. Manresa and Gomez (1937) report that the body temperatures of Nellore cattle at 6:00 a. m. were lower than those at 10:00 p. m. The temperatures at 10:00 a. m. were significantly lower than those at 2:00 and 6:00 p. m., and those at 2:00 and 6:00 p. m. were significantly higher than those observed at 10:00 p. m. Thus the body temperature in Nellore cattle is significantly higher during the day than at night.

The average body temperature of all the animals during the experiment was 38.89°C. This figure is higher than that given by Manresa and Gomez (1937), who found the average body temperature for the day in Nellore cattle to be 38.66 ± 0.022°C. Zialcita (1938), working on a Nellore bull, obtained an average body temperature of 38.7°C., which is higher than that reported by Manresa and Gomez, but still slightly lower than the average reported in the present study. The differences between the averages here reported were not significant.

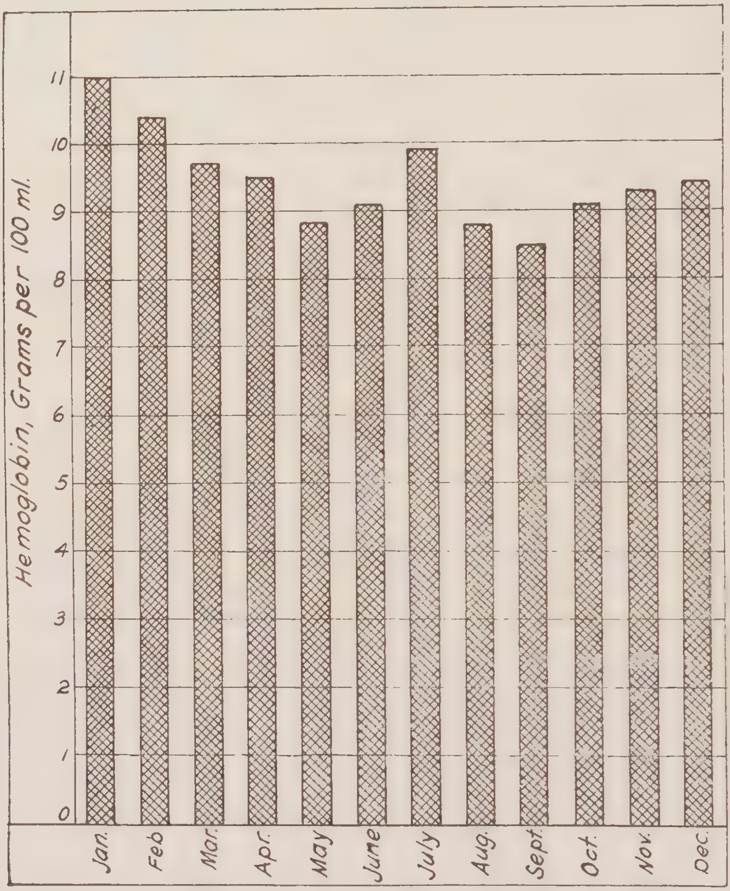

Chart 1.—Graphical representation of the monthly fluctuations in hemoglobin indices of male Nellore oxen.

Correlations between hemoglobin and atmospheric temperature, body temperature, and relative humidity

Correlations were figured to determine the degree of relationship between (*a*) hemoglobin indices and the atmospheric temperature, (*b*) hemoglobin and body temperature, (*c*) body temperature and atmospheric temperature, and (*d*) hemoglobin and relative humidity. The coefficient of correlation between hemoglobin and atmospheric temperature of –0.138 ± 0.037 shown in table 3 bears out the previous finding, reported by Manresa, Gomez, and Santos (1939), that the hemoglobin indices are negatively correlated with

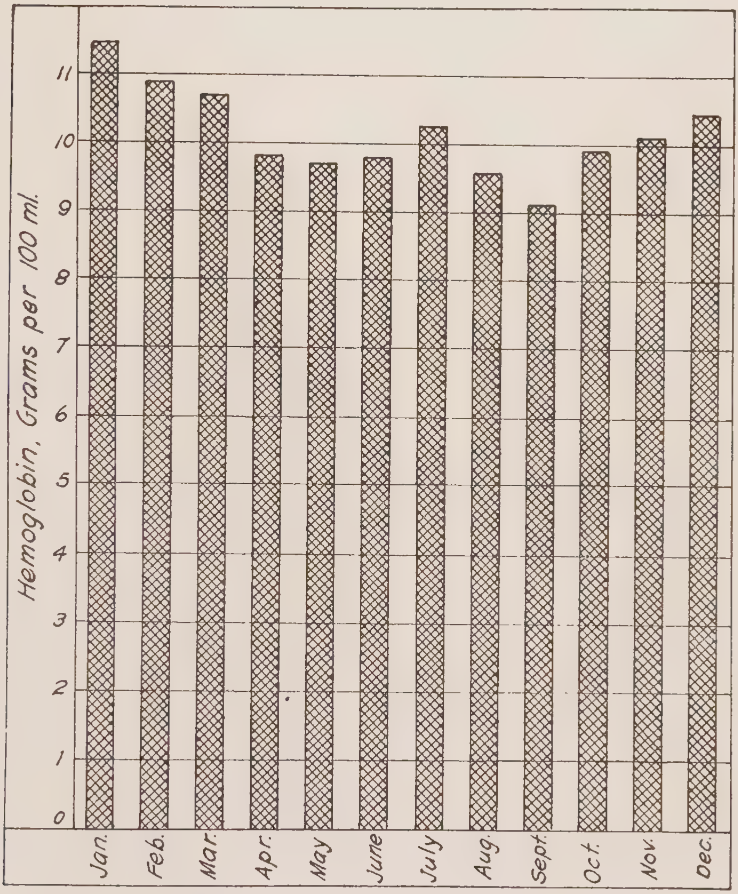

Chart 2.—Graphical representation of the monthly fluctuations in hemoglobin indices of female Nellore oxen.

the temperature of the air; that is, as air temperature rises there is a corresponding decrease in hemoglobin reading.

Since atmospheric temperature is positively correlated with the temperature of the animal's body, the coefficient of correlation being 0.337 ± 0.033 (table 3), it is not surprising that hemoglobin and body temperature should be negatively correlated. The coefficient of correlation was –0.183 ± 0.036, which is rather low but significant in showing the adverse effect of the rise in body temperature upon the hemoglobin content of the animal's blood. The correlation between body temperature and atmospheric temperature found by Manresa, Gomez, and Santos (1939) was 0.486 ± 0.0328. Their data, however, were obtained during the summer months only, and were of short duration, that is, for periods not exceeding seven days.

Of the four factors correlated with hemoglobin, relative humidity apparently showed the lowest correlation coefficient, namely, 0.076 ± 0.037, as may be seen in table 3. Manresa, Gomez, and Santos (1939) found very low correlation between the hemoglobin of Indian Nellore cattle and relative humidity. In his studies of the distribution of cattle in the United States, Davidson (1927) found that the combined effect of high temperature and high humidity practically eliminated the Holstein-Friesian breed in the southern states of the United States. It has been found that high temperature reduces the hemoglobin value of the Nellore cattle. Inasmuch as humidity has no effect on the hemoglobin content of the blood, it is possible that changes induced by high humidity, take place in other constituents of the blood.

Relationship between the hemoglobin and the different kinds of white blood corpuscles

A summary of the data on differential white blood cell counts for males and females as well as a summary for both males and females is presented in table 4.

Lymphocytes. It will be seen in table 4 that the percentages of lymphocytes did not vary greatly from month to month during the year. The average for the males was 50.22 ± 0.146 and for the females 52.54 ± 0.536 per cent. The difference in the percentage of lymphocytes between the males and the females is not statistically significant. The average for both males and females was 51.31 ± 0.203 per cent. Dimock and Thompson (1906) obtained an average percentage of lymphocytes in the blood of normal cattle of 54.20, whereas Zialcita (1938) found it to be 50.26 per cent in an Indian Nellore bull.

Large mononuclears. The monthly percentages of large mononuclears in both males and females, as seen in table 4, show that this type of cell varies within narrow limits from month to month during the year. The average percentage for the males was 3.73 ± 0.058, and for the females, 3.28 ± 0.053. The average for all the animals was 3.51 ± 0.080 per cent. This average is higher than that reported by Dimock and Thompson (1906), who found an average percentage of 1.40 for normal cattle. From a Nellore bull, Zialcita (1938) obtained 4.45 per cent, which is higher than that found in this study.

Polymorphonuclears. It appears that the percentages of polymorphonuclears fluctuated significantly in certain months of the year, but the fluctuations do not seem to follow the trend of the hemoglobin indices. It may be seen in table 4 that the average percentage for the males was 30.67 ± 0.129 and for the females, 29.68 ± 0.216. The difference, 0.99 ± 0.260 per cent, indicated that the males have significantly higher polymorphonuclear cell counts than the females. Moreover, the coefficients of variability show that in the males the polymorphonuclear cells are less variable. The average for both males and females was 30.18 ± 0.204 per cent. This figure is not far from the result obtained by Dimock and Thompson (1906), who found an average percentage for normal cattle of 30.50. Zialcita (1938) reported a percentage of 31.40 from a Nellore bull.

Eosinophiles. The percentage of eosinophiles varied greatly from month to month during the year. The average for the males was 14.59 ± 0.180 and for the females, 13.86 ± 0.248. The average for all the animals was 14.22 ± 0.289 per cent. Dimock and Thompson (1906) found it to be 13.15 and Zialcita (1938), 13.05.

Mast cells. The percentages of mast cells in the blood of Nellore cattle did not vary greatly from month to month during the whole period of the experiment. In the male animals, the average was 0.79 ± 0.125 per cent, and in the females, 0.77 ± 0.019 per cent. The average for both males and females was 0.78 ± 0.018 per cent.

This figure is slightly higher than that reported by Dimock and Thompson for normal cattle, but lower than that of Zialcita from a Nellore bull.

Graphic presentations of the relationship between the hemoglobin and the different kinds of white blood cells are given in chart 3. It may be seen in the chart that the monthly percentages of lymphocytes in the blood seemed to follow slightly the fluctuations in the hemoglobin indices. For example, the average hemoglobin indices for all the animals in the month of January was 11.22 grams per 100 cc. of blood, 10.64 for February, 10.19 for March, 9.68 for April, 9.26 for May, 9.41 for June, 10.04 for July, 9.25 for August, 8.85 for September, 9.55 for October, 9.70 for November, and 9.72 for December, whereas the average percentages of lymphocytes were: January, 52.75; February, 51.70; March, 52.20; April, 50.65; May, 50.75; June, 52.45; July, 50.40; August, 49.95; September, 50.25; October, 51.80; November, 51.10; and December, 50.90.

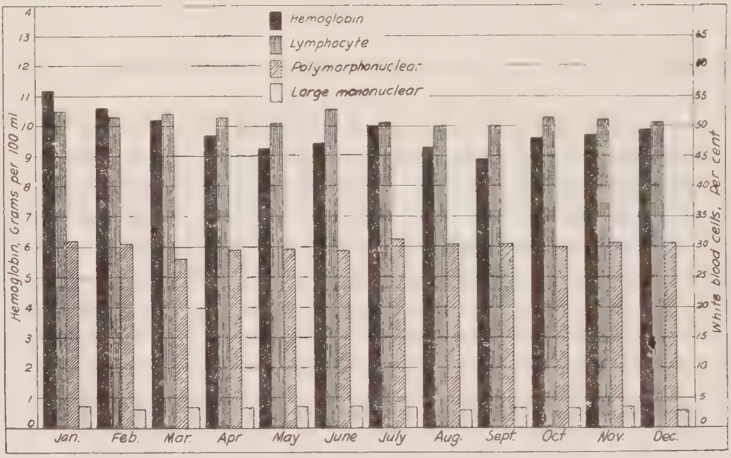

Chart 3.—Graphical representation of the monthly fluctuations in hemoglobin and differential white blood cell counts in Indian Nellore oxen.

The relationship between the hemoglobin indices and the values for large mononuclears shows, that the percentages of large mononuclears in the blood of Nellore cattle is not affected by the normal fluctuations of hemoglobin. Chart 3 also shows that, as the hemoglobin falls, the percentages of large mononuclears remain constant.

The monthly variations in the percentages of polymorphonuclears in the blood do not seem to follow the fluctuations in hemoglobin indices (Chart 3). For example, the hemoglobin indices during the month of March were higher than for April and May, but the percentages of polymorphonuclears for April and May were higher than for March. If the percentages of polymorphonuclears are compared with those of lymphocytes, it appears that the fluctuations in the former are not always followed by those of the latter in the same direction.

Chart 4 shows graphically the relationship between the hemoglobin, eosinophiles, and mast cells. Generally speaking, the percentages of eosinophiles in the blood were lower when those of the hemoglobin were high, and vice versa. Thus, during the months of March, April, May, August, and September, the hemoglobin indices were high; in other months, the opposite was true, except during the months of June and July.

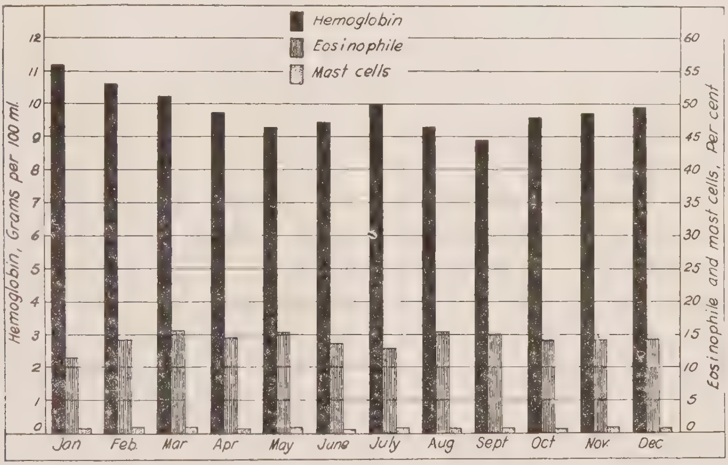

Chart 4.—Graphical representation of the monthly fluctuations of hemoglobin, eosinophiles, and mast cells in Indian Nellore oxen.

The percentages of mast cells in the blood were so low and so uniform that it was not advisable to correlate them with the fluctuations in hemoglobin indices.

A summary of the data obtained from the foregoing is tabulated below. The differential white blood cell counts reported by

Dimock and Thompson (1906) are here reproduced for purposes of comparison.

The percentages of differential white blood cells in Nellore cattle

VARIETIES OF CELLS	DATA FROM PRESENT WORK			DIMOCK AND THOMPSON (1906)		
	Min.	Max.	Av.	Min.	Max.	Av.
Lymphocytes	43.13	61.22	51.31	31.0	76.0	54.20
Large mononuclears	1.28	6.22	3.51	0.2	3.3	1.40
Polymorphonuclears	21.16	41.51	30.18	13.0	45.8	30.50
Eosinophiles	6.17	20.93	14.22	3.8	26.5	13.15
Mast cells	0	1.65	0.78	0.1	1.2	0.59

It will be seen from the data given above that the average percentage of lymphocytes obtained in the present study, namely 51.31, is lower than that reported by Dimock and Thompson for European cattle raised in the United States. The range of variation, which was from 43.13 to 61.22 per cent, is narrower than that reported by Dimock and Thompson (1906), namely, from 31.00 to 76.00 per cent. The average percentage of lymphocytes reported by Zialcita (1938) was 50.26, which is not far below the average reported in the present study. The narrow limits of variation in percentages of white blood cells in Nellore cattle found in lymphocytes applies to the large mononuclears and eosinophiles, but is not true of mast cells which showed variation of from 0 to 1.65 per cent, the average being 0.78 per cent. Dimock and Thompson reported the range of variation of mast cells to be from 0.1 to 1.2 per cent with an average of 0.59 per cent. The average of Zialcita (1938) was 0.85 per cent.

When the fluctuations in relative humidity were compared with those of different kinds of white blood cells, no agreement was found to exist nor any relationship between the hemoglobin indices and humidity. It seems likely that in animals which have already become acclimated to a given set of environmental conditions, such as the Indian Nellore in the College of Agriculture, the relative humidity does not affect the hemoglobin and white blood cells significantly.

SUMMARY AND CONCLUSIONS

1. A study of the hemoglobin indices in adult Indian Nellore cattle was conducted for a period of one year. The average hemoglobin index was found to be 9.79 grams per 100 ml. of blood.

2. In both the male and the female Nellore ox, the hemoglobin indices for the entire year show bimodal curves. The first curve is of seven months duration, starting from October and ending in April, with the mode in January. The rise and fall in hemoglobin indices, based on the modes, were gradual and fairly regular.

3. The body temperature of the Nellore cattle observed during the whole period of the experiment was found to be 38.89°C. It was positively correlated with atmospheric temperature.

4. The atmospheric temperature bears a reciprocal but negative relationship with the hemoglobin indices of the Nellore cattle.

5. The correlation coefficient between hemoglobin and body temperature was found to be negative. As the body temperature decreased, there was a corresponding rise in the hemoglobin index, or vice versa.

6. Normal fluctuations in hemoglobin indices did not affect appreciably the percentages of large mononuclears, polymorphonuclears, and mast cells. The trend in changes of percentages of lymphocytes was in the same direction as the hemoglobin except in the months of March and April.

7. The relationship between hemoglobin and eosinophiles showed an inverse relation. When the hemoglobin was high, the percentage of eosinophiles was low, and vice versa. This was not so, however, during the months of June and July.

8. The average percentages of the different varieties of white blood corpuscles in the Indian Nellore cattle studied were as follows: lymphocytes, 51.31; large mononuclears, 3.51; polymorphonuclears, 30.18; eosinophiles, 14.22; and mast cells, 0.78.

9. The hemoglobin indices were not correlated with relative humidity. The changes in the percentages of different types of white blood cells did not show definite agreement with the fluctuations in relative humidity throughout the entire year. It is probable, therefore, that relative humidity does not affect hemoglobin and white blood cell fluctuations in animals which have already become acclimated to a given set of environmental conditions, such as the Nellore ox in the Philippines.

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TABLE 1

Monthly averages of the hemoglobin determinations from January 2 to December 25, 1937

Grams per 100 ml.

NAME OF ANIMALS	SEX	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	AVERAGE
Acelo (H. No. 242)	Male	10.39	10.34	9.35	9.04	8.81	8.86	9.75	8.73	8.59	9.27	9.09	9.10	9.26
Nestor (H. No. 46)	"	10.36	9.57	9.38	9.35	8.39	8.85	9.04	8.09	8.25	8.79	9.16	9.13	9.03
Madras Last (H. No. 68)	"	12.00	11.04	10.33	10.19	9.26	9.84	10.76	9.64	8.63	9.57	9.58	9.96	10.04
Average	"	10.92	10.32	9.68	9.52	8.82	9.06	9.85	8.82	8.49	9.14	9.28	9.39	9.44
Rosal (H. No. 35)	Female	11.55	10.88	10.28	9.73	9.47	9.53	9.58	9.15	8.43	9.19	9.23	10.10	9.76
Rani (H. No. 41)	"	10.21	9.68	9.60	8.57	8.43	8.38	9.30	8.43	8.36	9.13	9.18	9.11	9.03
Daisy (H. No. 52)	"	12.77	12.32	12.18	11.19	11.17	11.38	11.77	11.21	10.57	11.29	11.96	12.13	11.66
Average	"	11.51	10.96	10.69	9.83	9.69	9.76	10.22	9.59	9.12	9.87	10.12	10.44	10.15
General average	"	11.22	10.64	10.19	9.68	9.26	9.41	10.04	9.25	8.85	9.55	9.70	9.72	9.79

TABLE 2

A summary of the physical examination of the blood of six Indian Nellore cattle from January 2 to December 25, 1937

NAMES OF ANIMALS	MONTHS	WEIGHT	HEMOGLOBIN INDEX; GRAM PER 100 ML.	BODY TEMPERATURE	ATMOSPHERIC TEMPERATURE	HUMIDITY
		kgm.	*grams*	*°C.*	*°C.*	*per cent*
Acelo No. 242	January	374.55	10.39	39.22	26.42	60.60
	February	368.18	10.34	39.43	26.87	48.00
	March	380.00	9.35	39.08	27.82	40.80
	April	418.18	9.04	39.05	29.25	41.50
	May	431.82	8.81	38.82	28.58	54.20
	June	468.18	8.86	39.05	28.33	55.25
	July	484.55	9.75	39.02	27.16	70.20
	August	490.91	8.73	39.03	27.38	68.00
	September	499.09	8.59	38.38	27.25	67.25
	October	504.55	9.07	38.86	27.38	62.60
	November	506.36	9.09	38.42	26.13	71.00
	December	484.55	9.10	38.83	26.70	60.00
	Average	450.91	9.26	38.98	27.42	58.25
Nestor No. 46	January	520.00	10.36	38.98	26.42	60.60
	February	534.55	9.57	38.93	26.87	48.00
	March	540.00	9.30	39.00	27.82	40.50
	April	519.09	9.35	39.05	29.25	41.50
	May	540.00	8.39	39.04	28.58	54.20
	June	532.73	8.85	39.08	28.33	55.25
	July	526.36	9.04	38.88	27.16	70.20
	August	529.09	8.09	39.10	27.38	68.00
	September	516.36	8.25	38.63	27.23	67.25
	October	512.73	8.79	38.76	27.38	62.60
	November	510.91	9.16	38.73	26.13	71.00
	December	513.64	9.13	38.70	26.70	60.00
	Average	524.62	9.03	38.91	27.42	58.25
Madras Last No. 68	January	392.09	12.00	39.16	26.42	60.60
	February	386.36	11.04	39.13	26.87	48.00
	March	380.91	10.33	39.15	27.82	40.50
	April	377.27	10.19	38.90	27.25	41.50
	May	400.00	9.26	39.02	28.58	54.20
	June	445.45	9.48	39.03	28.39	55.25
	July	463.64	10.76	39.16	27.16	70.20
	August	483.64	10.64	39.03	27.38	68.00
	September	490.91	8.63	38.83	27.23	67.25
	October	496.36	9.57	38.70	27.38	62.60
	November	501.82	9.58	38.60	26.30	71.00
	December	500.00	9.96	38.55	26.70	60.00
	Average	443.20	10.04	38.94	27.42	58.25
	General average for male	472.91	9.44	38.92	27.42	58.25

TABLE 2 Continued

NAMES OF ANIMALS	MONTHS	WEIGHT	HEMOGLOBIN INDEX; GRAM PER 100 ML.	BODY TEMPERATURE	ATMOSPHERIC TEMPERATURE	HUMIDITY
		kgm.	*grams*	*°C.*	*°C.*	*per cent*
Rosal No. 35	January	407.27	11.55	38.88	26.42	60.60
	February	386.82	10.88	38.78	26.87	48.00
	March	410.91	10.28	38.90	27.82	40.60
	April	394.55	9.73	39.03	29.25	41.50
	May	404.09	9.47	38.92	28.58	54.20
	June	406.36	9.53	39.10	28.33	55.25
	July	409.09	9.58	38.84	27.16	70.20
	August	400.91	9.15	38.90	27.38	68.00
	September	392.73	8.43	38.53	27.23	67.25
	October	399.09	9.19	38.60	27.38	62.60
	November	386.36	9.23	38.48	26.30	71.00
	December	360.00	10.10	38.58	26.70	60.00
	Average	396.52	9.76	38.79	27.42	58.25
Ranai No. 41	January	328.91	10.21	38.96	26.42	60.60
	February	322.73	9.68	38.65	26.87	48.00
	March	310.00	9.60	38.98	27.82	40.50
	April	318.18	8.57	39.05	29.25	41.50
	May	309.09	8.43	39.00	28.58	54.20
	June	336.36	8.38	39.00	28.33	55.25
	July	328.18	9.30	38.84	27.16	70.20
	August	356.36	8.43	38.85	27.38	68.00
	September	354.55	8.36	38.63	27.23	67.25
	October	353.64	9.13	38.96	27.38	62.60
	November	354.55	9.18	38.85	26.13	17.00
	December	359.09	9.11	38.75	26.70	60.00
	Average	335.97	9.04	38.88	27.42	58.25
Daisy No. 52	January	390.09	12.77	39.04	26.42	60.60
	February	384.55	12.32	38.85	26.87	48.00
	March	386.36	12.18	39.18	27.82	40.50
	April	374.55	11.19	39.10	29.25	41.50
	May	390.91	11.17	39.08	28.58	54.20
	June	377.27	11.38	39.18	28.33	55.25
	July	396.36	11.77	38.94	27.16	70.20
	August	400.00	11.21	39.23	27.38	68.00
	September	390.91	10.57	38.93	27.23	67.25
	October	384.55	11.29	38.84	27.38	62.60
	November	386.36	11.96	38.63	26.13	71.00
	December	372.73	12.13	38.70	26.70	60.00
	Average	386.22	11.66	38.97	27.42	58.25
Average for females		372.90	10.15	38.87	27.42	58.25
General average		422.91	9.79	38.89	27.42	58.25

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[1] Atmospheric temperature and relative humidities were in all cases at 2 o'clock p. m.

TABLE 3

The correlation between (a) hemoglobin and atmospheric temperature, (b) hemoglobin and body temperature, (c) body temperature and atmospheric temperature, (d) hemoglobin and relative humidity

CHARACTERS CORRELATED	r	Er	$\frac{r}{Er}$
(a) Hemoglobin and atmospheric temperature	—0.138	±0.037	4×
(b) Hemoglobin and body temperature	—0.183	±0.036	5×
(c) Body temperature and atmospheric temperature	+0.337	±0.033	10×
(d) Hemoglobin and relative humidity	+0.076	±0.037	2×

TABLE 4

Monthly averages of the differential white blood cell counts from January 2 to December 25, 1937

Males

NAMES OF CELLS	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	AVERAGE	S. D.	C. V.
Lymphocytes	51.1	50.7	49.7	49.4	49.3	50.3	49.5	49.3	50.6	51.1	51.3	50.5	50.22 ± 0.146	0.722 ± 0.099	1.438 ± 0.197
Large mononuclears	3.6	3.6	4.1	4.0	3.9	3.9	4.3	3.4	3.5	3.5	3.6	3.3	3.73 ± 0.058	0.288 ± 0.039	7.723 ± 1.063
Polymorphonuclears	31.7	30.7	20.1	30.7	30.4	30.4	31.5	30.8	30.4	30.6	30.5	31.3	30.67 ± 0.129	0.638 ± 0.087	2.082 ± 0.286
Eosinophiles	12.8	14.3	16.2	15.1	15.5	14.8	13.8	15.6	14.7	14.3	13.9	14.1	14.59 ± 0.180	0.888 ± 0.122	6.345 ± 0.873
Mast cells	0.8	0.7	0.9	0.8	0.9	0.6	0.9	0.9	0.8	0.5	0.7	0.8	0.79 ± 0.125	0.124 ± 0.017	15.725 ± 1.887

Females

NAMES OF CELLS	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	AVERAGE	S. D.	C. V.
Lymphocytes	54.4	52.7	54.7	53.9	52.2	54.6	51.3	50.6	49.9	52.5	50.9	51.3	52.54 ± 0.536	1.664 ± 0.229	3.174 ± 0.437
Large mononuclears	3.5	2.9	3.1	2.9	3.3	3.6	2.9	3.3	3.2	3.6	3.6	3.4	3.28 ± 0.053	0.265 ± 0.039	8.079 ± 1.112
Polymorphonuclears	30.4	30.1	27.0	28.6	28.5	28.7	32.1	30.1	30.6	29.4	30.4	30.3	29.68 ± 0.216	1.064 ± 0.146	3.584 ± 0.493
Eosinophiles	11.1	13.7	14.4	13.6	15.2	12.3	12.9	15.2	15.5	13.8	14.2	14.3	13.86 ± 0.248	1.223 ± 0.168	8.825 ± 0.121
Mast cells	0.6	0.6	0.8	0.9	0.8	0.8	0.8	0.8	0.8	0.7	0.9	0.7	0.77 ± 0.019	0.029 ± 0.041	3.874 ± 0.533

Averages for males and females

NAMES OF CELLS	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	AVERAGE	S. D.	C. V.
Lymphocytes	52.75	51.70	52.20	50.65	50.75	52.45	50.40	49.95	50.25	51.80	51.10	50.90	51.31 ± 0.203	1.002 ± 0.137	1.952 ± 0.268
Large mononuclears	3.55	3.25	3.60	3.45	3.60	3.75	3.6	3.35	3.35	3.35	3.60	3.35	3.51 ± 0.030	0.148 ± 0.020	4.227 ± 0.581
Polymorphonuclears	31.05	30.40	28.05	29.45	29.55	31.80	31.80	30.45	30.50	30.00	30.45	30.80	30.18 ± 0.204	1.008 ± 0.138	3.339 ± 0.459
Eosinophiles	11.95	14.00	15.30	14.35	15.35	13.55	13.35	15.40	15.10	14.05	14.05	14.20	14.22 ± 0.289	0.962 ± 0.132	6.761 ± 0.930
Mast cells	0.70	0.65	0.85	0.90	0.85	0.70	0.85	0.85	0.80	0.60	0.80	0.75	0.78 ± 0.018	0.090 ± 0.012	11.574 ± 0.241

WEATHER OBSERVATIONS AT THE COLLEGE OF AGRICULTURE, 1924-1937 [1]

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Of the Department of Agricultural Botany

WITH TWO CHARTS

Soon after the establishment of the College of Agriculture at Los Baños, Laguna, in 1909, weather observations were begun and most of the data gathered were used by members of the faculty and students. Incidentally, irrigation engineers, malaria control workers, personnel of certain insular bureaus and of the Philippine Army, as well as members of the National Research Council of the Philippines, have occasionally availed themselves of some of the data collected at the college weather station. Moreover, monthly reports are sent to the Weather Bureau, Manila.

Weather observations that were made from September, 1911, to December, 1912, were published monthly in the *Philippine Agriculturist and Forester*. No data were published from then until Estioko (1924)[2] prepared a summarized report on the weather observations from 1916 to 1924. The present report covers the observations made during the last fourteen years, from 1924 to 1937 inclusive, and includes data (*a*) on rainfall, (*b*) temperature of the air, (*c*) wind velocity, (*d*) evaporation and insolation, and (*e*) relative humidity of the air. Brief notes are also presented on typhoons and the occasional earthquakes that occurred during the period.

Rainfall. A standard rain gauge placed in an open field is used in collecting daily rainfall.

The data on rainfall were at first gathered twice a day, at 6:00 a. m. and at 6:00 p. m., but in October, 1934, when this Station was affiliated with the Weather Bureau, a third reading at 2:00 p. m. was started in order to conform with the practice followed by the Bureau.

To make a reading, a measuring stick, graduated into centimeters and millimeters, is thrust perpendicularly into the rain water collected in the receiving reservoir. The last wet graduation on the stick indicates the amount of rain water that has been collected. For example, if the water in the cylinder is 19 mm. in height, inasmuch as the area of the smaller cylinder is only one-tenth of the mouth of the funnel, the rainfall reading for the day would be 1.9 mm. If the rain is very heavy and the small cylinder can not hold all the water, the surplus water overflows into the big cylinder. The water in the small cylinder is first measured as described above. This cylinder is next emptied and the water in the big cylinder is transferred into it. The measuring stick is again used and another reading made. These two readings are added together and the result is the rainfall for the period. Rainfall at 2:00 o'clock in the afternoon is also recorded. The data gathered at 6:00 a. m. and at 6:00 p. m. are useful in determining the rainfall during the day and night as well as the precipitation in twenty-four hours. The data on monthly rainfall in millimeters for the period from 1924 to 1937 are given in table 1.

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[1] Experiment Station contribution No. 1310. Read before the Los Baños Biological Club, August 25, 1938.

[2] ESTIOKO, ROMAN P. 1924. Weather observations at Los Baños, 1916-1923. The Philippine Agriculturist 13: 407.

Temperature. The temperature of the air is taken with a U-thermometer, which records the maximum and minimum temperatures of the day, and with an ordinary thermometer, both of which are placed under a shelter. Before being used, these thermometers were compared with a standard thermometer borrowed from the Weather Bureau, Manila. The average maximum and minimum temperatures for the different months for the period from 1924 to 1937 inclusive, together with other pertinent data, are given in table 2.

Wind velocity. With a Friez' anemometer, the velocity of the wind (or perhaps, more properly, wind intensity) is measured daily. This apparatus is self-recording and is operated by four cups attached to the ends of two iron rods in such a way that they are held sidewise so as to catch the wind current and at the same time form a square. The point of intersection of the two rods connecting the cups is attached to a gear that turns the cogs of the apparatus. Because of their position, these two circular cogs are called outer and inner and are graduated in such a way as to record automatically the wind velocity or intensity in miles and tenths of a mile.

Data are recorded twice a day in order that wind velocity (*a*) during the day and during the night, (*b*) during the twenty-four hours, and (*c*) during a certain period of time may be compared. From the daily records, data were compiled to show also the monthly wind velocity or intensity, in miles, from 1924 to 1937 inclusive (table 3).

Evaporation and insolation. The data on the evaporating power of the air and the sunlight are determined with the use of one black and one white spherical atmometer. The reservoir bottles contain distilled water. The atmometers are those designed by Livingston. They have been previously standardized against known standards and each bears a certain coefficient. The reading in cubic millimeters taken from the black atmometer when multiplied by the coefficient of the cup gives the corrected reading; that is, the reading that corresponds to a certain standard. Similarly, the reading in cubic millimeters from the white atmometer, for the same period of time, in turn, when multiplied by its coefficient, gives the corrected reading. The corrected reading from the white atmometer records the evaporating power of the air. This figure when subtracted from the corrected reading from the black atmometer cup gives the evaporating power of the sunlight, or the so-called insolation. The average monthly data in cubic millimeters of evaporation and insolation are compiled for the period from 1924 to 1937 inclusive (table 4).

Relative humidity of the air. The relative humidity of the air is determined by a humidometer. The relative humidity is indicated by a pointer which moves automatically within the graduated scale of from 0 to 100, according to the amount of moisture present in the air at the time of reading. Data on percentage of humidity of the air are computed monthly from 1924 to 1937 inclusive (table 5).

DISCUSSION OF RESULTS

Rainfall. Examination of the data in table 1 and chart 1 reveals that the rainy months at the Agricultural College Station and its immediate vicinities were July, August, September, October, and November. The months of May, June, December, and January were intermediate, whereas February, March, and April were rather dry or had little rain.

Table 1 also shows that the daily rainfall ranged from 0 to 312.9 mm. The latter occurred in December, 1936; the second largest, 259.1 mm. in November, 1934; and the third, 171.4 mm. in October, 1937. In no case within the period of fourteen years did a month of continuous rain occur, but three months were without rain. Examination of the data on monthly precipitation shows that rainfall distribution ranged from 2.6 to about 708.9 millimeters. Twice in the dry years of 1926 and 1932 no rain was recorded in April, and once in March, 1934. The heaviest rains occurred in the months of July, August, September, October, and November, ranging from 54.9 to 708.9 millimeters. During the fourteen years, the rains were fairly well distributed throughout the months from July to November inclusive. On the other hand, uneven rainfall distribution occurred in the rest of the months, that is, from December to June inclusive. February, March, and April may be considered as

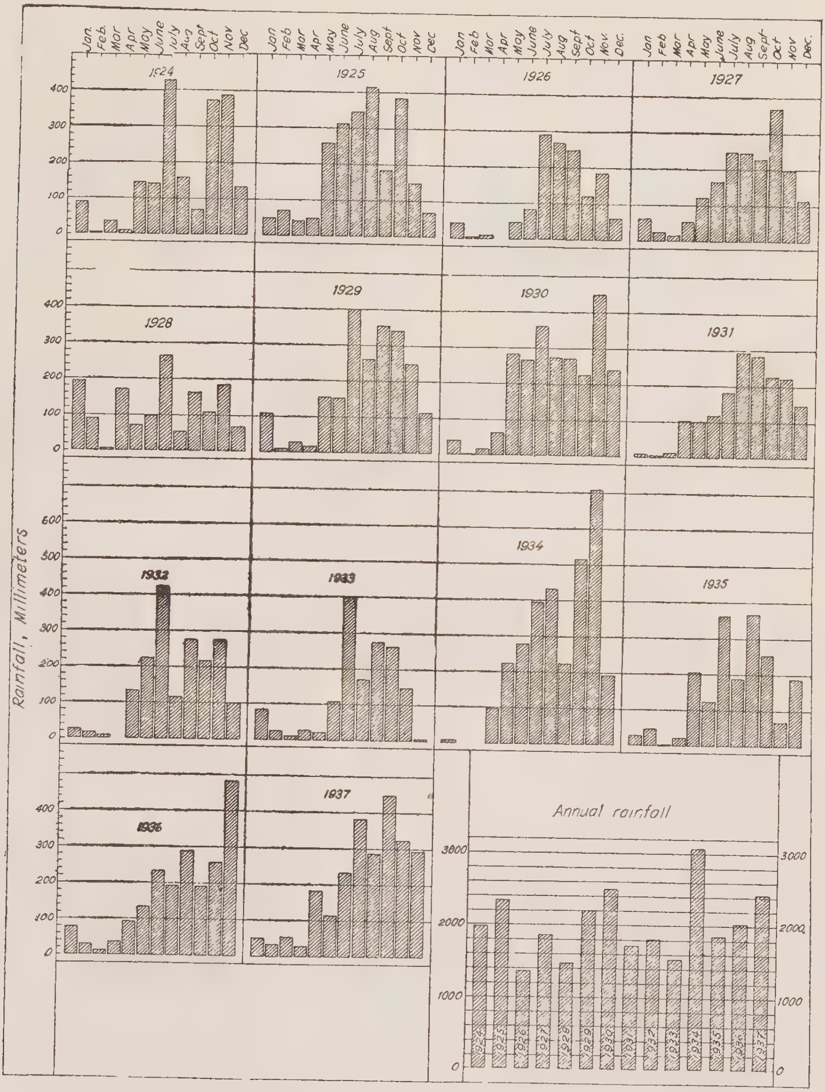

Chart 1.—Monthly rainfall at the Agricultural College Station, 1924-1937, inclusive.

the dry or summer months. During these dry months the amount of rainfall varied from 0 in February to 171.5 millimeters in April, distributed unevenly.

The years in which the annual rainfall did not exceed 1500 millimeters were 1926 with 1382.2 and 1928 with 1491.2 millimeters; the years not exceeding 2000 millimeters were 1933 with 1552.8, 1931 with 1726.2, 1932 with 1828.1, 1935 with 1875.8, 1927 with 1880.8, and 1924 with 1984.2 millimeters; and those less than 2500 milli-

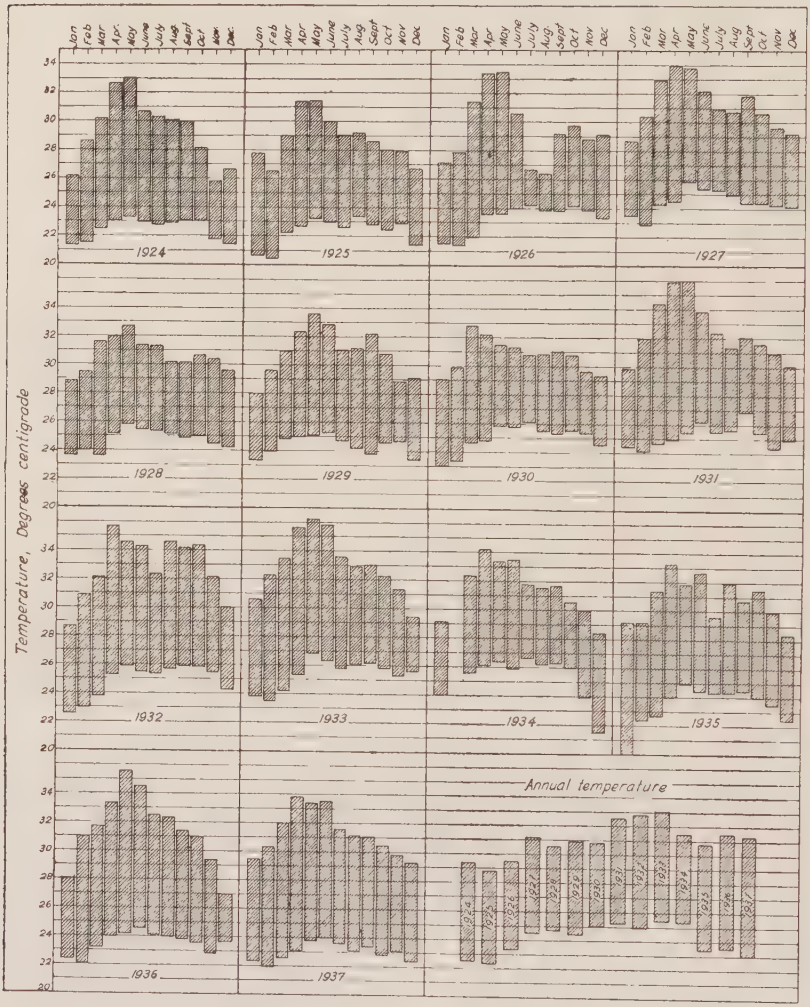

Chart 2.—Monthly temperature extremes at the Agricultural College Station, 1924-1937, inclusive.

meters were 1936 with 2048.7, 1929 with 2205.1, 1925 with 2352.2, and 1937 with 2445.3 millimeters. The years 1930 and 1934 had 2505.6 and 3088.2 millimeters, respectively. The last figure is somewhat higher than that reported by Estioko (1924). In short, the annual rainfall during the fourteen years (1924-1937) varied from 1382.2 to 3088.2 millimeters.

Temperature. The data on temperature in table 2 and chart 2 for the years 1924-1937 show that the highest monthly maximum temperature of the air, observed in May, 1933, was 36.3°C. The lowest was 25.8°C. in November, 1924, giving a range or a difference of 10.5°C. The highest minimum temperature was 26.9°C. in May, 1933, whereas the lowest was 20.0°C. in January, 1935, giving a range or a difference of 6.9°C.

The monthly average temperatures presented in table 2 show that high air temperatures in this locality were observed in March, April, May, and June. In addition, high air temperatures were observed in August or September for the years 1927 to 1936, inclusive.

The highest maximum day temperature was 38.5°C. observed in April, 1934. The second highest was 38.0°C. in May, 1931, and the third, 37.5°C., in April, 1933. On the other hand, the lowest maximum day temperatures were 23.2°C., 24.0°C., and 24.4°C. in September, 1932, October, 1929, and December, 1925, respectively. The highest minimum day temperatures were 31.0°C., 28.1°C., and 27.5°C. in June, 1934, August, 1931, and May, 1929, respectively. The lowest data were 17.3°C., 17.4°C., and 18.1°C. in December, 1924, February 1935, and January, 1925, respectively.

An analysis of the data on daily temperature (table 2) reveals the fact that the rise began in February and was steady until it reached the highest point in May. In the later part of May, however, the temperature began to drop lower and lower until it reached the lowest point in January or February, when the cycle began again.

The annual maximum air temperatures fluctuated from 28.8 to 33.1°C. These occurred in 1925 and 1933, respectively, giving a difference of 4.3°C. The data on minimum temperature varied also, from 22.3 to 25.4°C. within the same years, with a difference of 3.1°C. The average temperature for fourteen years was 27.6°C.

Wind velocity. The data presented in table 3 show that the monthly wind velocity varied from 197.0 to 4627.9 miles. It is also shown that the weaker winds prevailed during the rainy months between June and October inclusive. This velocity was the sum total for the entire month, including "baguios". Table 3 reveals also that daily wind velocity at the Agricultural College Station and its immediate surroundings within the period of study is very much stronger during the drier months from December to May inclusive than during the rainy months.

The highest day or 24-hour record of wind velocity which occurred on November 5, 1926, was 569.3 miles. Others were 506.0 and 444.7 miles, on November 15, 1934, and July 29, 1935, respectively. The lowest wind velocity was 0.6, 2.5, and 9.2 miles, in September, 1926, July, 1926, and October, 1927, respectively.

The annual wind velocity varies from 8861.9 to 40802.7 miles. The years 1925, 1926, 1924, 1934, and 1931 were less windy, the rates being from 8861.9 to 27677.7 miles; the years 1929, 1930, 1935, 1936, and 1937 were quite windy. The columns of monthly total and average as well as daily and hourly averages of wind velocity (table 3), show that November, December, January, February, March, April, and May are very windy. The figures under the columns of the daily and hourly averages represent fairly good data on wind velocity on the College Campus during the period under discussion. The great wind velocity, as shown either monthly or yearly, was the accumulation of daily strong winds and was not necessarily due to "baguios".

From the daily records during normal times, it is to be noted that winds are much stronger during the day than at night. There are records here, however, showing nights with wind velocity greater than during the day, but this is noted only in abnormal times or during stormy days. Also daily records reveal that most of the storms that have occurred so far on the College Campus began in the afternoon or at night. The prevailing winds are from the N.E., N.W., and S.E., seldom from the S.W.

Evaporation and insolation. These two climatic factors are measured at the same time. Table 4 contains the data on evaporation and insolation in cubic centimeters of water. An analysis of these data shows that the greatest amounts were obtained during the dry, windy months of February, March, April, May, and June. In 1927, 1928, 1933, and 1937, great amounts of evaporation-insolation were obtained. Such conditions as these occurred owing to the small amount of rain coupled with brightness of sun and the relatively high wind velocity. It is, therefore, clear that when rainy days set in, rapid evaporation and insolation are more or less checked. The daily evaporation records show that irrespective of month, if the day is clear, free from clouds, and at the same time windy, great amounts of water evaporate. The rates of evaporation and insolation, therefore, depend entirely upon climatic conditions, such as, clearness of the sky, humidity, and movement of wind. The daily record of evaporation ranges from 2.2 to 62.7 cc. and of insolation, 0.3 to 40.5 cc.

The data in table 4 further show that the lowest amounts of evaporation and insolation were obtained in the months of June, July, August, September, October, and November. The rates of insolation went as low as 126.3 cc. within 30 days, or an average of 2.5 cc. per day. The highest rates of evaporation, however, within the same number of days were 1722.9 cc. with an average daily rate of 57.4 cc. of insolation 1171.7 cc. with an average of about 39.1 cc. The lowest rates occurred in September, whereas the higest rates were in May. The rates of evaporation and insolation are greatest during the summer months. Both the total and average figures show, among other things, the trend of yearly evaporation as well as insolation. These data are more or less correlated with rainfall and wind velocity. Furthermore, the data under the columns "daily evaporation" and "insolation" are indices of the rates of water losses daily for a period of fourteen years from 1924 to 1937 inclusive.

Relative humidity and cloudiness. Humidity, in the broad sense of the term, means the amount of moisture present in the air at a given place and time. It has a direct relation to the rate of evaporation. Table 5 shows the data on humidity obtained at the Agricultural College Station for this period of observation. The average monthly moisture content of the air in this Station varied from 53 to 91 per cent. The average humidity for eleven years was 76.6 per cent.

Cloudiness is another important climatic factor. The daily records of evaporation and insolation revealed the fact that oftentimes evaporation as well as insolation are checked by extreme cloudiness. In some cases, however, although the day is cloudy, if the temperature of the air is high, the rate of water loss is also high. Data on cloudiness obtained at the College Station for the period show that the number of cloudy days is more than twice as great as that of clear days. Cloudy days occurred mostly during the rainy months, but they also occurred occasionally during the dry months. The daily records at the Agricultural College Station, during the period under discussion, show that the percentage humidity of the air ranged from 33 to 96.

Storms. Within the fourteen years of observation, there were over twenty-seven stormy days. Table 6 shows the data on wind velocity in miles and in kilometers per hour during storms. In this part of the country, "baguios" occur during two periods in the same year. The first "baguio" period of the year comes in July and August, and the second, in October, November, and December. As can be seen from table 6, wind velocity of the storms of the first period was very much weaker than that of the second. The table shows that the strongest storm occurred on November 5-6, 1926, with an average velocity of 55.93 miles per hour. Espino (1928)[3] made a report on the recuperative growth of plants injured during this storm. Another strong storm occurred on November 15, 1934, with a velocity of 44.60 miles per hour, and a third on November 24, 1928, with a velocity of 35.64 miles per hour. The weakest one was on August 19, 1927, with an average velocity of 16.67 miles per hour. In other words, the average rates of wind velocity observed and recorded in this locality ranged from 16.67 to 55.93 miles per hour.

Table 6 also shows the approximate duration of strong winds during storm. Strong winds during storm varied in length from eight to twelve hours.

Earthquakes. Although the Agricultural College Station does not have the apparatus for earthquake determination, a few of the strong ones have been observed. The strongest earthquake felt in this place occurred on August 20, 1937, at about 8:00 o'clock in the evening. The tremors lasted a few minutes. Magsaysay and Feliciano (1937)[4] reported that Manila and other parts of the Islands were badly affected by this same earthquake, and that Manila suffered the most both in loss of life and property. Destruction of property as a result of this earthquake was recorded in Paete, Cavinti, Mabitac, Nagcarlan, Pakil, Pañgil, Santa Maria, and other towns of the eastern part of Laguna. The second strongest was the one that occurred on April 4, 1937, at 5.10 in the morning. This, however, did not cause any destruction either to property or human life. The third, of very low intensity, occurred on March 21, 1938, at 3:28 in the afternoon.

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[3] ESPINO, R. B. 1928. Report on recuperative growths within a year of some plants injured by typhoon. The Philippine Agriculturist **17**: 89-93.

[4] MAGSAYSAY, A., AND JOSE M. FELICIANO. 1937. Preliminary study of the earthquake of August 20, 1937. National Research Council of the Philippine Islands Bulletin No. 14. December, 1937.

SUMMARY

1. The rainy months are July, August, September, October, and November. The months with moderate rainfall are May, June, December, and January; and the dry or summer months are February, March, and April. The data on rainfall here considered show that the daily precipitation ranged from 0 to 312.9 mm. The monthly rainfall ranged from 0 to 708.9 mm., whereas the annual rainfall ranged from 1382.2 to 3088.2 mm. Not a single month has been found to have continuous daily rain. Three months are credited with no rain.

2. The daily maximum temperatures ranged from 23.2 to 38.5°C., which extremes occurred in December and April, giving a difference of 15.3°C. The daily minimum temperature ranged from 17.3 to 31.0°C. occurring in December and June, respectively. The highest monthly maximum temperature of the air was 36.3°C. observed in May, 1933, and the lowest, 25.8°C. observed in November, 1924, giving a difference of 10.5°C. The highest minimum temperature was 26.9°C. in May, 1933, and the lowest, 20.0°C., in January, 1935, giving a difference of 6.9°C. The annual air temperatures fluctuated from 28.8°C. to 33.1°C. occurring in 1925 and 1933, respectively. The minimum varied from 22.3°C. to 25.4°C. observed in the years just mentioned.

3. The daily wind velocity varied from 0.6 to 569.3 miles which occurred in September, 1926, and November, 1926, respectively. The monthly wind velocity varied from 197.0 to 4627.9 miles, while the annual wind velocity varied from 8861.9 to 40802.7 miles. The dry summer months are more windy than the rainy ones.

4. The daily rates of evaporation and insolation varied from 2.2 to 62.7 cc. and 0.3 to 40.5 cc. respectively. The monthly rates were 126.3 to 1722.9 cc. whereas the annual, varied from 2749.0 to 11969.7 cc. Greater amounts of evaporation as well as insolation were observed during the dry months than during the rainy months. These rates are correlated with the variation of rain and wind.

5. The moisture content of the air is materially influenced by rains and cloudiness. The daily percentage of humidity of the air varied from 33 to 96, whereas the monthly percentage varied from 53 to 91.

6. Over twenty-seven stormy days were recorded during the fourteen years of observation. The average wind velocity during

stormy days varied from 16.66 to 55.93 miles or from 26.81 to 89.99 kilometers per hour. These storms came in two periods. The first period was during July and August and the second, during October, November, and December. "Baguios" that occurred during the latter period were much stronger than those that came during the first period.

7. Three earthquakes of varying intensities were noted.

TABLE 1

Monthly rainfall, in millimeters, in Agricultural College Weather Station from 1924 to 1937 inclusive

MONTH	1924	1925	1926	1927	1928	1929	1930	1931	1932	1933	1934	1935	1936	1937	MONTHLY AVERAGE RAINFALL FOR 14 YEARS
Jan. ...	91.1	51.7	43.8	65.4	195.8	108.8	40.8	10.8	22.8	85.5	8.7	29.7	80.9	52.0	63.4
Feb. ...	3.9	71.3	5.9	27.3	91.8	12.4	3.9	3.1	17.1	26.6	0	49.0	27.4	35.6	28.9
March ..	38.1	46.9	11.2	18.1	5.1	28.1	20.9	16.5	11.1	10.2	0	2.6	15.0	54.6	19.9
April ...	9.7	52.0	0	55.2	171.5	18.4	65.5	104.5	0	27.6	98.8	24.9	38.1	27.3	49.5
May ...	143.3	259.2	55.3	123.9	73.9	155.3	281.1	103.7	134.0	25.6	324.0	207.5	96.9	184.3	147.7
June ...	141.0	315.7	85.1	168.7	99.7	155.8	269.3	119.7	224.0	108.3	279.9	123.7	135.1	115.3	167.2
July ...	427.1	346.7	291.6	250.6	263.8	399.0	360.4	183.1	425.8	401.7	395.6	364.2	234.9	233.5	327.0
Aug. ...	160.2	417.6	270.8	250.8	54.9	261.2	275 0	296.9	116.2	171.8	434.8	187.7	194.0	385.9	248.4
Sept. ..	70.2	184.0	247.6	234.7	165.6	356.5	272.5	287.1	278.2	276.0	223.5	368.8	290.0	287.4	253.0
Oct.	373.7	386.3	123.3	369.6	113.8	342.9	226.1	228.5	217.4	264.7	517.1	257.6	190.6	448.4	290.0
Nov. ...	387.3	148.9	186.1	199.2	185.1	250.2	449.7	223.9	279.6	147.4	708.9	68.5	259.8	323.9	272.7
Dec. ...	138.6	71.9	61.5	117.3	70.2	116.5	240.4	148.4	102.9	7.4	196.9	191.6	486.0	297.1	160.5
Annual .	1984.2	2352.2	1382.2	1880.8	1491.2	2205.1	2505.6	1726.2	1829.1	1552.8	3088.2	1875.8	2048.7	2445.3	—

TABLE 2

Monthly temperatures in °C. in Agricultural College Weather Station from 1924 to 1937 inclusive

MONTH	1924		1925		1926		1927		1928		1929		1930		1931	
	Max.	*Min.*	*Max.*	*Min.*	*Max.*	*Min.*	*Max.*	*Min.*	*Max.*	*Min.*	*Max.*	*Min.*	*Max.*	*Min.*	*Max.*	*Min.*
January	26.2	21.3	27.8	20.7	27.2	21.5	28.7	23.5	28.9	23.6	28.0	23.3	29.1	23.0	29.9	24.4
February	28.6	21.5	26.6	20.4	27.9	21.4	30.4	22.9	29.5	24.0	29.6	24.0	29.9	23.3	32.0	24.1
March	30.2	22.5	29.0	22.2	31.4	22.0	32.9	24.3	31.6	23.6	31.0	24.9	32.8	24.6	34.4	24.6
April	32.7	23.1	31.4	22.7	33.4	23.6	33.9	24.5	32.0	25.1	32.4	25.0	32.2	24.7	35.9	24.9
May	33.0	23.3	31.4	23.2	33.5	23.6	33.6	25.9	32.7	25.8	33.6	25.1	31.5	25.9	36.0	25.4
June	30.7	23.0	30.0	23.0	30.6	24.0	32.2	25.4	30.9	25.5	32.9	25.2	31.3	25.8	33.9	26.2
July	30.3	22.8	29.1	22.6	26.7	24.2	30.9	25.3	30.9	25.4	31.1	24.7	30.8	26.1	32.4	25.5
August	30.2	22.9	29.2	23.3	26.4	23.8	30.7	25.0	30.2	25.1	31.2	24.2	30.9	25.5	31.4	25.6
September	30.0	23.1	28.6	22.8	29.2	23.8	31.8	24.3	30.2	24.9	32.2	23.8	31.1	25.3	32.1	26.8
October	28.2	23.1	28.0	22.4	29.8	24.1	30.6	24.4	30.7	25.0	30.8	24.6	30.8	25.5	31.6	25.4
November	25.8	21.8	27.9	22.8	28.8	23.8	29.6	24.2	30.4	24.5	28.9	24.7	29.6	25.3	31.0	24.3
December	26.7	21.5	26.7	21.4	29.1	23.3	29.2	24.1	29.6	24.3	29.1	23.4	29.3	24.5	30.1	24.9
Average	29.4	22.5	28.8	22.3	29.5	23.3	31.2	24.5	30.6	24.7	30.9	24.4	30.8	25.0	32.6	25.2
Range of average monthly max. and min.	6.9		6.5		6.2		6.7		5.9		6.5		5.8		7.4	
Range for the year	11.7		11.0		12.1		11.0		9.1		10.3		9.8		11.9	
Mean range for 14 years	—		—						—		—		—		—	

TABLE 2 Continued

MONTH	1932		1933		1934		1935		1936		1937		MONTHLY AVERAGE FOR 14 YEARS		MEAN MONTHLY RANGE FOR 14 YEARS
	Max.	*Min.*	*Max.*	*Min.*	*Max.*	*Min.*	*Max.*	*Min.*	*Max.*	*Min.*	*Max.*	*Min.*	*Max.*	*Min.*	
January	28.7	22.6	30.7	23.8	29.2	24.0	29.2	20.0	28.1	22.4	29.5	22.3	28.7	22.6	6.1
February	30.9	23.0	32.3	23.5	—	—	29.2	22.3	31.0	22.1	30.3	21.9	29.9	22.6	7.3
March	32.1	23.8	33.5	24.2	32.4	25.6	31.4	22.7	31.7	23.2	32.0	22.6	31.9	23.6	8.3
April	35.7	25.3	35.7	25.3	34.2	26.1	33.3	24.0	33.3	24.0	33.8	23.1	33.6	24.4	9.2
May	34.6	25.9	36.3	26.9	33.4	26.3	31.9	24.9	35.6	24.2	33.4	23.8	33.6	25.0	8.6
June	34.3	25.5	35.8	26.4	33.5	25.9	32.7	24.4	34.5	24.6	33.5	24.0	32.6	24.9	7.7
July	32.4	25.4	33.6	25.8	31.8	26.6	29.6	24.3	32.5	24.1	31.6	23.6	31.0	24.8	6.2
August	34.6	25.7	33.0	26.1	31.6	26.2	32.0	24.3	32.3	24.0	31.2	23.1	31.1	24.6	6.5
September	34.2	25.9	33.1	26.2	31.7	26.3	30.7	24.4	31.4	23.8	31.1	23.4	31.2	24.6	6.5
October	34.4	25.9	32.3	25.8	30.6	26.0	31.5	24.0	31.0	23.6	30.5	22.8	30.8	24.5	6.3
November	32.2	25.5	31.4	25.3	30.0	23.9	30.0	23.5	29.4	22.8	29.8	23.1	29.6	24.0	5.6
December	30.1	24.3	29.5	25.6	28.5	21.6	28.4	22.4	27.0	23.7	29.3	22.4	28.8	23.4	5.4
Average	32.8	24.9	33.1	25.4	31.5	25.3	30.8	23.4	31.5	23.5	31.3	23.0	31.1	24.1	—
Range of average monthly max. and min.	7.9		7.7		6.2		7.4		8.0		8.3		—		—
Range for the year	13.1		12.8		12.6		13.3		13.5		11.9				
Mean range for 14 years	—		—		—		—		—		—		7.0		6.86

TABLE 3

Monthly wind velocity or intensity, in miles, in Agricultural College Weather Station from 1924 to 1937 inclusive[a]

MONTH	1924	1925	1926	1927	1928	1929	1930	1931	1933	1934	1935	1936	1937	MONTHLY AVERAGE FOR 13 YEARS	DAILY AVERAGE FOR 13 YEARS	HOURLY AVERAGE FOR 13 YEARS
January	1933.4	1314.7	1324.4	3204.7	2509.8	3110.9	2951.4	3288.2	2851.2	2498.2	3394.5	3128.8	2887.1	2646.0	85.36	3.56
February	2179.0	1244.4	1439.1	2515.7	2837.8	3483.0	3125.8	3021.8	2972.7	—	3164.4	2973.6	2939.8	2658.1	94.93	3.96
March	2437.0	1311.4	1851.2	3652.7	2574.0	4286.0	4553.7	3343.7	3815.9	1920.7	3978.2	4627.9	3418.9	3213.2	103.65	4.32
April	2268.2	1048.4	804.8	2616.8	2588.0	4122.6	3032.9	3665.2	4040.2	2636.5	4094.8	4240.6	4239.4	3030.6	101.02	4.21
May	2088.6	655.3	961.0	2662.5	1720.0	4451.9	3002.7	2373.0	4055.6	3419.7	2232.7	4581.2	3196.5	2723.1	87.84	3.66
June	1093.3	543.1	961.7	1696.0	1547.0	3093.3	2137.3	1897.7	1813.3	1839.4	2310.1	3071.0	2810.4	1908.7	63.62	2.65
July	2307.0	832.9	564.2	2149.0	1639.5	1845.0	4013.2	1548.1	2335.3	2264.4	3993.4	3109.8	3740.1	2334.0	75.29	3.14
August	2126.3	403.2	676.6	2144.0	1922.3	2886.5	2063.0	2964.4	1911.2	1425.9	4124.8	2773.2	3124.6	2195.8	70.83	2.95
September	1428.0	307.1	412.0	1805.0	2488.2	1598.8	1658.2	1828.3	2370.6	1669.9	2796.3	2267.7	2490.9	1778.5	59.28	2.47
October	1137.3	197.0	371.1	2354.0	2641.9	1792.3	1986.0	1431.9	2121.0	1690.4	2839.6	3349.3	3207.4	1932.2	62.33	2.60
November	891.7	215.9	1522.1	2027.5	3302.2	2695.8	2552.2	888.2	2823.9	3606.4	3804.9	2878.1	3823.6	2387.1	79.57	3.32
December	2055.0	788.5	1741.4	2286.2	2249.9	3080.5	2764.8	1427.2	2519.4	3221.9	3517.4	3801.5	3633.8	2545.2	82.10	3.42
Total for the year	21944.8	8861.9	12629.9	29114.1	28020.6	36446.6	33841.2	27677.7	33630.3	26193.4	40251.1	40802.7	39512.5			
Monthly average	1828.7	738.5	1052.5	2426.2	2335.1	3037.2	2820.1	2306.5	2802.5	2381.2	3354.3	3400.2	3292.7			
Average hourly intensity	2.505	1.011	1.370	3.322	3.197	4.217	3.863	3.160	3.839	3.238	4.595	4.692	4.541			
Mean for 13 years														2446.0	80.48	3.36

[a] Data for 1932 are not available.

TABLE 4

Monthly evaporation and insolation, in cubic centimeters of water, in Agricultural College Weather Station from 1924 to 1937 inclusive[a]

MONTH	1924		1925		1926		1927		1928		1931	
	Evaporation	Insolation	Evaporation	Insolation	Evaporation	Insolation	Evaporation	Insolation	Evaporation	Insolation	Evaporation	Insolation
January	410.6	242.7	483.1	320.7	403.6	244.3	773.3	240.6	579.5	361.8	633.2	422.7
February	603.7	227.4	441.2	229.1	436.2	226.1	789.8	265.8	560.0	342.7	541.9	347.4
March	525.4	280.5	588.8	314.8	692.0	357.1	1079.9	316.6	1002.2	595.4	611.9	402.2
April	991.6	734.3	670.7	328.0	—	—	1157.0	469.6	968.7	546.7	720.0	497.9
May	865.0	419.1	606.4	362.1	—	—	1097.4	512.8	888.5	487.6	770.5	—
June	556.0	416.8	126.3	75.3	469.0	354.9	581.7	507.6	613.8	371.8	632.8	240.1
July	441.1	250.1	356.2	222.5	447.0	281.9	970.5	332.5	555.7	376.1	625.1	281.4
August	446.1	268.5	375.8	217.3	322.4	245.0	1004.9	392.4	1065.5	665.7	486.5	240.9
September	322.9	242.0	296.9	168.4	286.1	251.9	595.1	467.3	624.1	384.1	490.3	290.4
October	308.2	262.2	357.2	238.3	357.0	212.0	532.7	371.1	649.8	392.2	574.2	301.2
November	232.7	198.7	386.0	267.6	511.3	290.9	506.5	340.4	591.3	403.0	366.7	183.5
December	—	—	389.8	269.4	523.0	284.9	469.1	282.6	—	—	337.9	188.9
Total for the year	5703.3	3542.3	5078.4	3013.5	4447.6	2749.0	9657.9	4499.3	8099.1	4927.1	6791.0	3396.6
Monthly average	518.5	322.0	423.2	251.1	444.8	274.9	804.8	374.9	736.3	447.9	565.9	308.8
Daily average for 9 years	17.1	10.6	13.6	8.3	14.6	9.0	26.5	13.7	24.2	14.8	18.1	10.2
Mean for 9 years	—	—	—	—	—	—	—	—	—	—	—	—

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[a] Data for 1929, 1930, 1932, 1934, and 1935 are not available.

TABLE 4 Continued

MONTH	1933		1936		1937		MONTHLY AVERAGE FOR 9 YEARS		DAILY AVERAGE FOR 9 YEARS	
	Evaporation	Insolation	Evaporation	Insolation	Evaporation	Insolation	Evaporation	Insolation	Evaporation	Insolation
January	419.7	332.2	369.9	190.3	447.9	252.5	502.3	289.8	16.20	9.35
February	470.5	310.1	479.9	231.3	583.5	254.9	545.2	270.5	19.47	9.66
March	858.9	319.8	668.8	328.7	858.6	267.8	765.2	353.6	24.68	11.41
April	1215.2	797.6	851.3	451.0	953.1	388.1	940.9	526.6	31.36	17.55
May	1722.9	1171.7	1103.1	454.9	700.6	482.3	969.3	555.8	31.27	17.93
June	1570.9	751.5	797.9	343.6	661.4	382.7	667.8	382.7	22.26	12.76
July	1665.3	950.8	494.0	252.7	551.9	299.8	678.5	360.9	21.89	11.64
August	1043.0	757.4	531.4	290.9	468.7	199.1	638.3	364.1	20.59	11.75
September	876.2	620.6	438.2	246.3	376.7	190.1	489.6	317.9	16.32	10.60
October	853.6	631.1	796.8	265.7	535.7	272.5	551.7	327.4	17.80	10.56
November	739.4	486.3	379.4	207.9	348.1	240.0	451.3	290.9	15.04	9.70
December	534.1	371.0	350.9	222.5	421.4	296.9	432.3	273.7	13.96	8.87
Total for the year	11969.7	7500.1	7261.6	3485.8	6907.6	3526.7	—	—	—	—
Monthly average	997.5	625.0	605.1	290.5	575.6	293.9	—	—	—	—
Daily average for 9 years	32.8	20.6	19.9	9.5	18.9	9.6	—	—	—	—
Mean for 9 years	—	—	—	—	—	—	636.0	359.5	20.90	11.81

TABLE 5

Monthly percentage of atmospheric humidity in Agricultural College Weather Station from 1924 to 1937 inclusive[a]

MONTH	1924	1925	1926	1929	1930	1931	1933	1934	1935	1936	1937	MONTHLY AVERAGE FOR 11 YEARS
January	86	90	74	—	88	59	71	74	71	76	75	76.4
February	85	88	76	—	84	58	70	—	71	62	73	74.1
March	84	80	78	—	85	63	62	—	60	60	71	71.5
April	80	80	75	—	84	53	64	71	57	59	68	69.1
May	84	81	76	—	87	62	67	77	69	60	73	73.6
June	88	80	81	85	89	63	72	78	65	67	74	76.5
July	89	79	87	85	89	69	75	—	77	72	77	79.9
August	89	79	79	85	91	67	76	—	76	74	78	79.4
September	88	79	79	80	89	80	77	—	74	75	79	80.0
October	90	82	79	74	89	85	77	83	73	77	77	80.5
November	90	77	79	65	89	87	77	84	70	78	79	79.5
December	90	76	80	65	87	87	76	83	70	78	78	79.6
Annual average	86.9	80.9	78.6	77.0	87.6	69.4	72.0	78.6	69.4	69.8	75.2	—
Mean for 11 years	—	—	—	—	—	—	—	—	—	—	—	76.6

[a] Data for 1927, 1928, and 1932 are not available.

TABLE 6

Wind velocities during stormy days at the College of Agricultural Weather Station from 1924 to 1937 inclusive

DATE OF OCCURRENCE	APPROXIMATE DURATION	DISTANCE TRAVELLED IN	RATES PER HOUR	
	hour	*miles*	*miles*	*kilometers*[a]
November 5, 1926	10	559.3	55.93	89.99
August 19, 1927	12	200.0	16.67	26.82
November 24, 1928	8	285.1	35.64	57.34
August 5, 1929	12	262.6	21.88	35.20
July 12, 1931	12	205.0	17.08	27.48
August 15, 1931	10	225.0	22.50	36.20
August 16, 1931	12	237.5	19.80	31.86
November 15, 1934	10	446.0	44.60	71.76
November 30, 1934	10	179.2	17.92	28.83
July 29, 1935	10	232.7	23.27	37.44
July 30, 1935	10	247.6	24.76	39.84
July 31, 1935	12	271.2	22.60	36.36
August 1, 1935	12	270.9	22.57	36.30
August 3, 1935	8	167.9	20.99	33.77
August 4, 1935	10	197.7	19.77	31.80
August 5, 1935	12	265.7	22.14	35.62
August 6, 1935	12	216.4	18.03	29.01
November 17, 1935	12	215.7	17.97	28.91
October 9, 1936	10	177.1	17.71	28.50
December 2, 1936	8	265.8	33.22	53.45
July 28, 1937	12	204.6	17.05	27.43
August 2, 1937	12	258.5	21.54	34.66
October 15, 1937	8	234.4	29.30	47.14
November 11, 1937	8	198.5	24.81	39.92
November 18, 1937	12	205.2	17.10	27.51
November 19, 1937	12	246.5	20.54	33.05
December 6, 1937	8	138.1	17.26	27.78

[a] 1 mile = 1.609 kilometers.

HYDROGENATION OF MIXED OILS[1]

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The hardening of oils is now being undertaken on an extensive commercial scale in the candle, soap and vegetable shortening industries. The hardening process, called hydrogenation, consists in saturating the glycerides of the various fatty acids to change them to hard solid fats at ordinary temperature. In the Philippines where the supply of lard is limited, the need of some kind of vegetable shortening which is both palatable and economical is important. In some sections of the country, because of the high cost of lard and the abundance of coconut oil, the latter is used in the liquid state for cooking purposes. The peculiar odor and taste of the oil in this condition make it inferior to lard and, hence, not popular among housewives. In some countries, people refrain from the use of lard for religious reasons, and in vegetable shortening they find an answer to their needs. Lately, lards of vegetable origin made in the United States and in the Philippines have appeared in the local market. Their composition and process of manufacture have not been disclosed, but it is known that they are essentially hydrogenated cottonseed oil or mixtures of coconut oil with either oleostearine, soybean, cottonseed, fish or palm oils—all imported products. A large number of vegetable oils are produced in the Philippines but their suitability for hydrogenation, alone or mixed with coconut oil, have not been investigated; hence, the present work was undertaken.

REVIEW OF LITERATURE

The only work on hydrogenation of oils done in the Philippines is by West and Gonzaga (1923), who studied the hydrogenation of lumbang, palomaria, coconut, and pilinut oils, separately, using nickel catalyst from nickel carbonate. They found that "for a definite period of absorption, an increase in the concentration of nickel gave a decrease in the iodine value and an increase in the melting point" of the products formed. They claimed 180°C. to be the most satisfactory temperature for the hydrogenation of the foregoing oils.

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[1] Experiment Station contribution No. 1311.

Whereas pilinut oil gave a satisfactory product of iodine value 0.7 with a melting point of 66°-66.8°C. coconut oil did not harden readily, and after twenty-five hours of hydrogenation with a 3 per cent catalyst, the product became a solid but had a low melting point, 32°C.; hence, its use as a lard substitute could not be popular.

Sugborough, Watson, and Athawale (1922) hydrogenated cottonseed, linseed, mohar, sesame, sardine, peanut, castor, hongay, and coconut oils at 180°C. using nickel as catalyst.

Ueno, Yamashita, Ota, and Okamura (1927) hydrogenated coconut oil at 120°C. and claimed the products of the hydrogenation to be glycerides of saturated acids and of oleic acid, stable to light and air, confirming the work of West and Gonzaga (1923).

OBJECTS OF THE WORK

Table 1 shows that coconut oil differs materially from lard in composition. Although coconut oil contains large quantities of the glycerides of the saturated fatty acids, hydrogenation of this oil alone yields a product unsatisfactory as a lard substitute because of its low solidification and melting point (28°C.). On the other hand, pilinut and peanut oils approximate lard in composition. Kapok [*Ceiba pentandra* (Linn.) Gaertn.] seeds are a waste product of the kapok industry. The oil in the seeds is not usually extracted since there seems to be no market for it. It takes two kilos of the seeds to produce one liter of the oil. The composition of the oil according to Cruz and West (1931b) indicates similarity to cottonseed. Kapok oil has been used as substitute for cottonseed oil in the manufacture of soap. The present work attempts (*a*) to study the possibility of hydrogenating peanut and kapok oils from seeds grown in the Philippines as well as coconut oil mixed with oils such as pilinut, peanut, and kapok, and (*b*) to study the character of the resulting products and how they compare with vegetable shortenings now sold in the market.

MATERIALS AND METHODS

The coconut oil used in the present work was obtained from coconut milk by the bacterial method (Soliven and de Leon, 1938). The other oils were obtained by grinding pilinut (*Canarium ovatum* Engl.) seeds, peanuts (*Arachis hypogaea* Linn.), and kapok seeds and pressing the ground product in a Carver hydraulic press at 10,000 lbs. per square inch. The oil produced was clarified by means of kiesulghur and treated with anhydrous sodium sulfate.

Hydrogen was supplied from a tank at 1400 lbs./sq. in. pressure. The gas was purified by passing it through a gas purifying train consisting of two Dreschel bottles filled with saturated KOH and $KMnO_4$ solutions and a large U-tube filled with granular calcium chloride. A one liter round bottom Pyrex flask provided with a rubber stopper with three holes, one to admit the hydrogen gas from the gas train, the other to serve as gas outlet, and the third to provide an opening for the glass stirrer, was used as the hydrogenation chamber. A half inch hole was bored in the wall of the flask and a thermometer provided with a rubber stopper inserted in it. Samples enabling one to follow the progress of the hydrogenation were obtained through this opening.

The catalyst used in this work was of nickel-aluminum prepared by the Central Scientific Co., Chicago, and sold under the trade name of Raney Catalyst Powder. The catalyst under ordinary conditions must be activated before being used. The activation consisted in treating the powder with a solution of sodium hydroxide of 23°Be to decompose the aluminum with the liberation of hydrogen gas, digesting the sludge for two hours, and washing it until free of alkali. Since the activated catalyst is pyrophoric when exposed to the air, it was covered with coconut oil and the excess water still present driven off by heating the sludge to 149°C. The catalyst upon analysis was found to be 52.63 per cent nickel; in other words, 1.9 grams of the catalyst was equivalent to 1 gram nickel. Since in each trial 100 grams of oil were used, by using 3.8 grams of the catalyst equivalent to 2 grams of nickel, the hydrogenation was said to be conducted with a 2 per cent catalyst.

The activated nickel catalyst and the different oils, separately and in mixtures, were introduced into the hydrogenation chamber. This, in turn, was immersed in an oil bath heated to 180°–190°C. at which temperature the hydrogenation process was conducted. Samples were removed at intervals by means of a pipette without stopping the hydrogenation process. The samples were treated with Norit, filtered through a hot water funnel, and the iodine value (Hanus method) and the melting point of the resulting products determined. The iodine value of a fat or oil indicates the degree of saturation; the melting point, suggests its suitability as shortening agent.

The oils were first hydrogenated separately in order that the behavior with the Raney catalyst might be studied. Previous work on the hydrogenation of pilinut and peanut oils has been done with activated nickel carbonate. Mixtures of the oils in different proportions were next studied.

It is a common commercial practice in the United States to carry the hydrogenation of cottonseed oil down to an iodine number of 10-20 and then to treat this hardened product with liquid cottonseed oil, after which process the product is frozen or again hydrogenated to the desired consistency and iodine number. This procedure lowers the cost of production. The highly hydrogenated product is sometimes used in the manufacture of prepared cake flour (Bisquick). In the Philippines, vegetable shortening is used not only for cooking purposes but also as the basis of another industry, the making of nut margarine often called artificial butter. Local manufacturers prepare their "butter" by agitating either Crisco, Purico, or similar products with powdered milk, then adding artificial food color. The mixed product is frozen and packed in tin cans or oiled paper wrappers. Such "butter" need not have a very high melting point but must be hard enough to remain solid for the interval of time exposed during a meal, after which it again hardens in a refrigerator. The use of highly hydrogenated material mixed with oil of the same substance in order to have a product of fairly reasonable melting point for making margarine butter would result in economy in cost of production.

In the study of the behavior of the mixed oils hardened for twenty hours for the purpose of making margarine butter, the hydrogenated products were mixed with coconut oil in 1:1, 1:2, and 1:3 ratios, heated to effect complete homogenization and chilled. The iodine values and melting points of the products were afterwards determined.

INTERPRETATION OF RESULTS

Tables 2 to 9 give the average results of two to three trials made of each oil and mixtures of oils, taking from four to five determinations in each trial. The results obtained by hydrogenating coconut oil alone with the use of varying concentrations of the Raney catalyst may be compared with results obtained by the hydrogenation of coconut oil with the use of activated nickel obtained from nickel carbonate. West and Gonzaga (1923) hydrogenated coconut oil with a 3 per cent activated nickel catalyst (obtained from nickel carbonate) for ten hours and obtained a product of iodine value 0.7, melting point 32°–41°C. In the present work, with a 4 per cent catalyst, a product of iodine value 2.98, melting point 29°–34°C., was obtained after eighteen hours (table 2). The oil did not solidify even after twenty hours when the concentration of the catalyst was only 3 per cent.

Comparing the results obtained in the case of pilinut oil, West and Gonzaga (1923) reported a product of iodine number 3.9, melting point 62°–65°C. after ten hours using a 3 per cent catalyst. With a 3 per cent Raney catalyst and hydrogenation for ten hours, the product obtained had an iodine value of 18.29, melting point 51°–57°C. (table 2).

The present results indicate that activated nickel from nickel carbonate is more efficient than the Raney catalyst as a hydrogenating agent. However, the difficulty and extreme care that must be exercised in the activation of nickel carbonate as to avoid the "poisoning" of the catalyst, and the consequent waste of materials, labor, and time when such poisoning takes place, compared with the ease in the activation process of the Raney catalyst and the small danger of poisoning the catalyst, make the use of the latter preferable despite the efficiency of the former.

Jamieson (1932) in his treatise on "Vegetable Fats and Oils" reports the hydrogenation of peanut oil of iodine value 37.4 and melting point 51°C. No details are given as to the method of hydrogenation followed. No work on the hydrogenation of kapok oil has been reported. Results reported in table 3 obtained by the use of the Raney catalyst, cannot, therefore, be compared. The hydrogenation of peanut oil with the Raney catalyst indicates that, with a 3 per cent catalyst and hydrogenation for twelve hours, a product having an iodine value of 21.43 and melting point 51.5°–58.5°C., is obtained. With a 2 per cent catalyst and hydrogenation for twenty hours, the product obtained has an iodine value of 26.33, melting point 46°–53°C. (table 3).

In the case of kapok oil, using a 3 per cent catalyst and hydrogenating for twenty hours gave a product of iodine value 45.26, melting point 31°–38.5°C. By increasing the concentration of the catalyst to 4 per cent, only sixteen hours hydrogenation was required to yield a product having an iodine value of 27.16, melting point 48°–55°C. (table 3).

The mixture of coconut and pilinut oils in the ratio of 1:1 (table 4), with 1 per cent nickel used as catalyst, showed that only soft solids can be obtained during the first ten hours. After twelve hours, these become harder with melting point of 38–45.5°C. The iodine value lowered from 33.15 of the original mixture to 17.92 of the hardened product. When the concentration of the catalyst was increased to 2 per cent, hardened products having iodine value 17.30 and melting point of 38°–46°C. were obtained after eight hours. With a 3 per cent catalyst, hardened products were obtained after six hours hydrogenation, with an iodine value 16.62 and melting point 38°–46.5°C.

It is seen that the time needed to harden a mixture of 1:1 coconut and pilinut oils varies with the amount of catalyst used; the higher the percentage of catalyst, the lesser the time required and the higher the melting point. While these findings would suggest the possibility of using larger amounts of the catalyst to shorten the hydrogenation process, such conclusion would be misleading since the cost of the catalyst (₱10.00 per kilogram) and its effect on the product should be kept in mind.

Since coconut oil is the cheaper oil of the two in the mixture and the natural tendency is to use more of it, a different mixture using 2 parts of coconut oil and 1 of pilinut oil was also tried. A third mixture using 3 parts coconut oil and 1 part pilinut oil was, likewise, tried. That the effect of the use of different concentrations of the catalyst might be studied, 1 per cent, 2 per cent, and 3 per cent catalysts were tried. In the 1:2 mixture (table 4) with a 1 per cent catalyst, partially hardened products were obtained after twenty hours hydrogenation. With a 2 per cent catalyst, the products after sixteen hours gave an iodine value of 8.67 and melting point 37.5°–43.5°C. Increasing the catalyst concentration to 3 per cent shortened the period of hardening to ten hours, the product having an iodine value of 9.00, melting point 37°–44°C.

In the 1:3 mixture (table 4) with a 2 per cent catalyst, no hardening took place even after twenty hours hydrogenation. With a 3 per cent catalyst, however, after fourteen hours a solid product of iodine value 6.29 and melting point 31°–37°C. was obtained.

The same trend of results was observed in mixtures of 1:2 and 1:3 pilinut and coconut oils as those in the 1:1 mixture; that is, the higher the percentage of catalyst used, the less the time it took for the mixture to harden. Mixtures of 1:4 (table 4) show that even though a concentration of a 3 per cent catalyst is used in hydrogenation for twenty hours only a soft solid is produced. Results obtained indicate that with a 2 per cent catalyst, the quantity of coconut oil should be limited to 1:2 ratio if a product of satisfactory melting point is desired. A higher proportion of coconut oil yields a product similar to that obtained by hydrogenating coconut oil alone.

Table 5 gives the results obtained with peanut oil and coconut oil. Mixtures of 1:1 with a 1 per cent catalyst failed to harden in twenty hours. With a 2 per cent catalyst, and after fourteen hours of hydrogenation, a solid product was obtained having an iodine value of 18.96 and a melting point of 37°–44°C. The original mixture had an iodine value of 50.60. With a 3 per cent catalyst, the time was reduced to six hours, the product having an iodine value of 18.78, melting point, 37.5°–45.5°C. With a larger amount of coconut oil, 1:2, (table 5) the use of a 2 per cent catalyst produced no hardening even after twenty hours. Increasing the concentration of the catalyst to 3 per cent, and hydrogenating for twelve hours, a product of iodine value 9.93 and a melting point of 37°–45.5°C. was obtained. The iodine value of the orignal mixture was 33.20. Increasing the ratio to 1:3, a 3 per cent catalyst only yielded a soft solid even after twenty hours of hydrogenation (table 5).

Table 6 presents the results obtained by hydrogenating mixtures of kapok oil and coconut oil. With a 1:1 mixture and a 3 per cent cataylst, only a soft solid was obtained after twenty hours. However, with a 4 per cent catalyst a hardened product of iodine value 18.96, melting point, 37°–44.5°C. was obtained after ten hours. The iodine value of the original mixture was 49.13. Increasing the amount of coconut oil to 1:2 (table 6) required a 4 per cent catalyst before a hardened product was obtained after hydrogenating for sixteen hours. This product had an iodine value of 11.12 and melting point 34°–41°. similar to the hydrogenated coconut oil reported by West and Gonzaga (1923). The iodine value of the original mixture was 32.14.

The above results obtained with peanut and kapok oils, show that peanut oil mixed with coconut oil in 1:1 and 1:2 proportions yields satisfactory products which may be used as vegetable shortenings provided at least a 3 per cent catalyst is used. With kapok oil, a mixture of 1:1 and a 4 per cent catalyst is needed to obtain a satisfactory product. The 1:2 mixture hydrogenated for sixteen hours produces a solid product but of rather low melting point. The product is yellowish in color. It is possible that the use of a purified kapok oil and high pressure may shorten the period of hydrogenation and give products comparable in color to those obtained from coconut-pilinut mixtures.

In the hydrogenation of kapok oil and coconut-kapok oil mixtures, it was observed that hydrogenation for over twelve hours resulted in a tendency to yield darker products. This behavior may be due to either the action of the catalyst or a decomposition of the hydrogenated product. It has been observed that the final products gave a positive test for the presence of nickel by the alpha benzaldoxime method, which is sensitive to the extent of 1 part nickel in 2,000,000 parts of water. This is a problem which needs study.

The results of the homogeny of hardened oils with coconut oil are presented in tables 7 and 8. It is seen that the hydrogenated pilinut oils, with the use of a 3 per cent, 2 per cent, or 1 per cent catalyst, when mixed with coconut oil in equal proportions, yield satisfactory products in so far as melting point and solidifying qualities are concerned. With a 3 per cent catalyst used for the hydrogenated product, the admixture had a melting point of 41°–46°C.; that with a 2 per cent catalyst, 30°–43.5°C.; and that hardened with 1 per cent catalyst, 35°–43.5°C. Addition of coconut oil to hydrogenated pilinut tended to lower the melting point of the hardened oil. If a homogenized product of satisfactory melting point is to be obtained, the hydrogenated oil to be mixed must be one of high melting point.

The hydrogenated peanut-coconut mixture (1:1), when subjected to the same process gave satisfactory results, except that in which a 1 per cent catalyst was used. The mixture of hydrogenated products, wherein a 3 per cent catalyst and coconut oil in equal proportions were used, gave a product of satisfactory hardness, melting at 39°–44°C.; the product wherein a 2 per cent catalyst was used melted at 33°–37°C.

In the case of the hydrogenated kapok-coconut mixture, only that product in which the hydrogenation was done with a 4 per cent catalyst hardened when homogenized with an equal quantity of coconut oil, the resulting product melting at 35.5°–40.5°C.

In an attempt to find out the effect of using more coconut oil, one part of the hydrogenated product was mixed with 2 parts of coconut oil (table 8); the mixture was homogenized and chilled as before. Only the 3 per cent hardened pilinut-coconut mixture formed a solid after admixture, the resulting product having a melting point of 29.5°–33.5°C. The other mixtures formed semi-solid products.

The products obtained were compared with vegetable shortenings locally sold. These are shown in table 9. Both the iodine values and the melting points of the prepared mixtures compare favorably with those sold in the local market.

Shortening on being heated to a certain temperature smokes owing to the decomposition of the fat. This decomposition temperature is important when the fat is used for frying since the food absorbs some fat and the products of the decomposition affect the palatability of the food. Acrolein, one of the decomposition products is extremely unpleasant both to the eye and the respiratory system. Purico was observed to smoke approximately between 200–320°C.; the coconut-pilinut hydrogenated product, 200°–320°C.; coconut-peanut, 150°–270°C.; and, coconut-kapok, 140°–255°C. The shortening power of the hydrogenated products were compared with those of Purico by frying thin slices of potatoes (2mm.), dried between filter paper and dropped on the melted fat at 130°C. The fried potatoes compare favorably both in crispiness and flavor with those fried in Purico.

SUMMARY AND CONCLUSIONS

The results obtained in this work both with separate oils and mixtures of oils confirmed previous findings that during hydrogenation of an oil, the absorption of hydrogen by the unsaturated glycerides of the oil results in the lowering of the iodine value and elevation of the melting point of the hardened products. The results also show that in oil mixtures hydrogenated with different amounts of catalysts for a definite period of absorption, an increase in the concentration of nickel results in a decrease in the iodine value and an increase in the melting point. The Raney catalyst powder is simpler to use and gives approximately the same results as nickel catalyst from nickel carbonate. The hydrogenation of peanut and kapok oils for varying lengths of time with different amounts of catalyst is reported.

In the oil mixtures, the greater the amount of coconut oil used, the harder it was for the mixture to solidify. The proportion of coconut oil to be used depends on the character of the oil with which it is to be mixed. Pilinut oil and coconct oil are ideal mixtures since they yield solidified products in a very short time and require only a small concentration of the catalyst. Mixtures of coconut oil and peanut oil also gave good products comparable in some respects to mixtures of pilinut and coconut oils. Kapok seed and coconut oil mixtures gave products of inferior quality.

Suitable vegetable shortening can be prepared from pilinut oil and coconut oil. Mixtures of 1:1 gave good products when hydrogenated for six hours with a 3 per cent nickel catalyst; for eight hours with a 2 per cent catalyst; and for twelve hours with a 1 per cent catalyst. Mixtures having proportions of 1:2 yielded good products when hydrogenated for ten hours with a 3 per cent catalyst, and for eighteen hours with a 2 per cent catalyst.

Suitable products were obtained from mixtures of peanut oil and coconut oil in the proportion of 1:1 hydrogenated for six hours with a 3 per cent catalyst and for sixteen hours with a 2 per cent catalyst. Mixtures in the proportion of 1:2 required fourteen hours with a 3 per cent catalyst.

In the case of mixtures of kapok seed oil and coconut oil, a 4 per cent catalyst and ten hours hydrogenation are required to obtain products of satisfactory melting point. The rather large amount of catalyst needed makes the use of kapok less desirable than pilinut and peanut oils. However, with the low cost of kapok oil obtained from a waste product considered, the low cost of the oil may possibly offset the high cost of the catalyst.

The cost of production may be decreased by admixing coconut oil to the hydrogenated mixture, the resulting product being especially adapted for the margarine industry.

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TABLE 1

Chemical composition of lard and oils

GLYCERIDES OF		LARD [a]	COCONUT [b]	PILINUT [c]	PEANUT [d]	KAPOK [e]	M. P.
							°C.
Caproic	$C_6H_{12}O_2$	—	2.0	—	—	—	16.0
Caprylic	$C_8H_{16}O_2$	—	9.0	—	—	—	16.5
Capric	$C_{10}H_{20}O_2$	—	10.0	—	—	—	31.3
Lauric	$C_{12}H_{24}O_2$	—	45.0	—	—	—	43.6
Myristic	$C_{14}H_{28}O_2$	0.4	20.0	—	—	0.5	53.6
Palmitic	$C_{16}H_{32}O_2$	24.6	7.0	30.2	8.5	15.9	62.6
Stearic	$C_{18}H_{36}O_2$	15.0	5.0	1.8	3.6	2.3	69.3
Arachidic	$C_{20}H_{40}O_2$	—	—	—	3.4	0.8	77.0
Lignoceric	$C_{24}H_{48}O_2$	—	—	—	2.4	—	80.5
Oleic	$C_{18}H_{34}O_2$	50.4	2.0	59.6	53.9	49.8	14.0
Linolic	$C_{18}H_{32}O_2$	10.0	—	—	27.0	29.3	18.0
Unsaponifiable matter		—	—	0.20	0.3	0.8	—
Iodine Value		53–61	7.5–9.5	56–61	90–95	86–98	—

[a] Myddleton and Barry. 1924. Fats, natural and synthetic. p. 14. London.
[b] Elsdon (1913).
[c] West and Balce (1923).
[d] Cruz and West (1931a).
[e] Cruz and West (1931b).

TABLE 2

Hydrogenation of coconut and pilinut oils

HOURS OF HYDROGENATION	COCONUT OIL [a]				PILINUT OIL [b]					
	With 4 per cent nickel		With 3 per cent nickel		With 3 per cent nickel		With 2 per cent nickel		With 1 per cent nickel	
	Iodine value	Melting point	Iodine value	Melting point	Iodine value	Melting point	Iodine value	Melting point	Iodine value	Melting point
		°C.		°C.		°C.		°C.		°C.
2	5.35	liquid	5.52	liquid	46.52	29.5–35	50.31	liquid	53.37	liquid
4	4.68	”	5.18	”	36.05	37–46.5	42.24	32–38	47.17	”
6	4.18	”	4.87	”	28.35	44–51.5	35.31	29–46	42.48	32–37.5
8	3.80	”	4.59	”	22.02	47.5–54	29.37	42.5–49.5	38.41	35–42.5
10	3.59	”	4.35	”	18.29	51–57	24.53	46–52.5	34.22	40–47
12	3.40	”	4.17	”	15.06	52–60	20.59	50–56	30.05	42.5–49.5
14	3.23	”	4.03	”	11.79	54–61.5	18.18	51–57	27.00	45–51.5
16	3.10	”	3.93	”	8.64	56–64	16.35	52–58	24.05	47–53.5
18	2.98	29–34	3.88	”	5.71	59–67	15.49	52–60	21.29	49–55.5
20	2.90	29–35	3.83	”	3.13	60–69.5	14.76	53–60.5	19.84	50–56

[a] Iodine value before hydrogenation is 6.07

[b] Iodine value before hydrogenation is 60.04

TABLE 3

Hydrogenation of peanut and kapok seed oils

HOURS OF HYDROGENATION	PEANUT OIL [a]						KAPOK SEED OIL [b]					
	With 3 per cent nickel		With 2 per cent nickel		With 1 per cent nickel		With 4 per cent nickel		With 3 per cent nickel		With 2 per cent nickel	
	Iodine value	Melting point	Iodine value	Melting point	Iodine value	Melting point	Iodine value	Melting point	Iodine value	Melting point	Iodine value	Melting point
		°C.		°C.		°C.		°C.		°C.		°C.
2	65.87	liquid	75.66	liquid	79.23	liquid	74.77	liquid	80.23	liquid	84.96	liquid
4	40.66	32–39	60.70	”	68.68	”	60.57	”	69.15	”	78.01	”
6	32.61	39–47	50.47	”	61.24	”	48.56	28–35	62.44	”	71.35	”
8	27.39	46–52	44.83	”	54.36	”	40.30	34.5–42	57.56	”	65.51	”
10	24.56	49–55.5	39.92	33–39.5	49.05	”	34.30	40–48	53.33	”	61.42	”
12	21.43	51.5–58.5	36.93	36–42.5	45.29	”	30.26	44.5–51.5	51.21	”	57.43	”
14	19.22	53–60	32.85	39–46	42.38	”	28.25	47–54	49.14	”	53.91	”
16	18.25	54–61	29.86	41–47.5	39.83	32–39	27.16	48–55	47.40	28.5–36	51.48	”
18	17.17	55–62	28.02	44–50	37.97	34–40.5	26.22	49–56	46.07	30–37.5	49.56	”
20	16.40	55.5–62.5	26.33	46–53	35.89	37–42.5	25.31	49–57	45.26	31–38.5	49.14	”

[a] Iodine value before hydrogenation is 95.46

[b] Iodine value before hydrogenation is 93.20

TABLE 4

Hydrogenation of mixtures of pilinut and coconut oils in various proportions

HOURS OF HYDROGENATION	IN THE PROPORTION OF 1:1 [a]					
	With 3 per cent Ni		With 2 per cent Ni		With 1 per cent Ni	
	Iodine value	Melting point	Iodine value	Melting point	Iodine value	Melting point
		°C.		°C.		°C.
2	26.07	Liquid	28.08	Liquid	29.19	Liquid
4	20.63	Soft solid	23.91	"	26.52	"
6	16.62	38–46.5	20.34	Soft solid	24.17	"
8	13.33	42–50	17.30	38–46	22.12	"
10	11.33	44.5–52.5	14.81	41–48.5	20.03	Soft solid
12	9.65	46.5–54	12.79	43–50.5	17.92	38–45.5
14	8.53	48–55	11.55	45–51.5	16.38	39–46.5
16	7.56	49.5–56	10.60	46–52.5	14.91	40–48.5
18	6.94	49.5–57	10.14	46.5–53	13.51	41–49.5
20	6.70	50–57.5	9.80	46.5–53.5	12.80	41.5–50

[a] Iodine value of mixture before hydrogenation is 33.15.

TABLE 4 Continued

HOURS OF HYDROGENATION	IN THE PROPORTION OF 1:2 [b]					
	With 3 per cent Ni		With 2 per cent Ni		With 1 per cent Ni	
	Iodine value	Melting point	Iodine value	Melting point	Iodine value	Melting point
		°C.		°C.		°C.
2	19.21	Liquid	20.63	Liquid	21.91	Liquid
4	15.38	"	17.79	"	19.71	"
6	12.70	"	15.40	"	18.16	"
8	10.40	40–50% solid	13.30	"	16.75	"
10	9.00	37–44	11.57	"	15.36	"
12	7.82	39–45.5	10.19	"	13.90	"
14	7.02	40–46.5	9.33	60% solid	12.91	"
16	6.34	40–47	8.67	37.5–43.5	11.93	"
18	5.91	41.5–48	8.36	37.5–44	11.53	"
20	5.74	42–48.5	8.08	38 –44.5	10.66	40–50% solid

[b] Iodine value of mixture before hydrogenation is 24.06.

TABLE 4 Continued

HOURS OF HYDROGENATION	IN THE PROPORTION OF 1:3 [c]				IN THE PROPORTION OF 1:4 [d]	
	With 3 per cent Ni		With 2 per cent Ni		With 3 per cent Ni	
	Iodine value	Melting point	Iodine value	Melting point	Iodine value	Melting point
		°C.		°C.		°C.
2	15.81	Liquid	16.90	Liquid	13.82	Liquid
4	12.90	"	14.75	"	11.65	"
6	10.75	"	12.63	"	9.57	"
8	8.94	"	11.27	"	8.13	"
10	7.84	"	9.94	"	7.22	"
12	6.91	"	8.88	"	6.40	"
14	6.29	31–37	8.22	"	5.91	"
16	5.76	33–38.5	7.71	"	5.56	"
18	5.40	33–39	7.55	"	5.23	Soft solid
20	5.26	33–39.5	7.39	"	5.13	40% solid

[c] Iodine value of mixture before hydrogenation is 19.14.
[d] Iodine value of mixture before hydrogenation is 16.84.

TABLE 5

Hydrogenation of peanut and coconut oils in various proportions

HOURS OF HYDROGENATION	IN THE PROPORTION OF 1:1 [a]					
	With 3 per cent Ni		With 2 per cent Ni		With 1 per cent Ni	
	Iodine value	Melting point	Iodine value	Melting point	Iodine value	Melting point
		°C.		°C.		°C.
2	35.72	Liquid	40.72	Liquid	42.63	Liquid
4	22.94	”	33.08	”	37.33	”
6	18.78	37.5–45.5	27.93	”	33.57	”
8	16.03	42–49.5	25.06	”	30.11	”
10	14.49	43–50	22.48	”	27.45	”
12	12.83	44.5–51.5	20.47	”	25.56	”
14	11.65	46–52.5	18.96	37–44	24.09	”
16	11.11	46–53	17.37	38–45.5	22.80	”
18	10.52	46.5–53.5	16.43	39–47.5	21.85	”
20	10.12	47–54	15.56	41–49.5	20.82	”

[a] Iodine value of the mixture before hydrogenation is 50.60.

TABLE 5 Continued

HOURS OF HYDROGENATION	IN THE PROPORTION OF 1:2 [b]				IN THE PROPORTION OF 1:3 [c]	
	With 3 per cent Ni		With 2 per cent Ni		With 3 per cent Ni	
	Iodine value	Melting point	Iodine value	Melting point	Iodine value	Melting point
		°C.		°C.		°C.
2	25.68	Liquid	29.07	Liquid	20.63	Liquid
4	17.01	”	23.93	”	14.06	”
6	13.85	”	20.40	”	11.57	”
8	12.18	”	18.42	”	10.30	”
10	11.10	”	16.68	”	9.42	”
12	9.93	37–45.5	15.13	”	8.50	”
14	9.10	38–46.5	14.22	”	7.82	”
16	8.71	38–47	13.19	”	7.49	5% solid
18	8.30	38–47.5	12.55	”	7.17	80% ”
20	8.03	40–47.5	11.99	”	6.97	Soft solid

[b] Iodine value of the mixture before hydrogenation is 33.20.
[c] Iodine value of the mixture before hydrogenation is 27.12.

TABLE 6

Hydrogenation of a mixture of kapok and coconut oils in various proportions

HOURS OF HYDROGENATION	IN THE PROPORTION OF 1:1 [a]				IN THE PROPORTION OF 1:2 [b]	
	With 4 per cent Ni		With 3 per cent Ni		With 4 per cent Ni	
	Iodine value	Melting point	Iodine value	Melting point	Iodine value	Melting point
		°C.		°C.		°C.
2	40.06	Liquid	43.00	Liquid	28.50	Liquid
4	32.65	"	37.29	"	23.31	"
6	26.38	"	33.76	"	19.00	"
8	22.06	Soft solid	30.65	"	15.97	"
10	18.96	37–44.5	27.38	"	13.84	"
12	16.83	40–47.5	26.16	"	12.36	"
14	15.73	41–48.5	24.38	"	11.57	Soft solid
16	15.14	42–49	22.79	"	11.12	34–41
18	14.60	42–49.5	21.71	"	10.45	34–41.5
20	14.11	43–50	21.04	Soft solid	10.23	34.5–42

[a] Iodine value before hydrogenation is 49.13.
[b] Iodine value before hydrogenation is 32.14.

TABLE 7

Admixing some hydrogenated products with coconut oil in the proportion of 1:1

HARD PRODUCTS USED	ADMIXING HARDENED PILINUT OIL WITH COCONUT			
	Iodine value of hard product used	Melting point of hard product used	Admixture	
			Iodine value	Melting point
		°C.		°C.
3%—hardened	9.63	60–69	7.79	41–46
2%—hardened	14.70	53–60	10.45	30–43.5
1%—hardened	19.88	50–56	12.94	35–40
Admixing hardened peanut oil with coconut oil				
3%—hardened	16.35	56–62.5	11.22	39–44
2%—hardened	26.52	48.5–52.5	16.30	33–37
1%—hardened	35.99	37–42	20.95	60% solid
Admixing hardened kapok oil with coconut oil				
4%—hardened	25.22	49.5–57	15.74	35.5–40.5
3%—hardened	45.39	31–38	25.74	55% solid

TABLE 8

Admixing hydrogenated products with coconut oil in the proportion of 1:2

HARD PRODUCTS USED	ADMIXING HARDENED PILINUT OIL WITH COCONUT			
	Iodine value of hard product used	Melting point of hard product used	Admixture	
			Iodine value	Melting point
		°C.		°C.
3%—hardened	9.48	60–66.5	7.23	29.5–33.5
2%—hardened	14.81	53–59.5	8.95	soft solid
1%—hardened	19.79	50.5–57	11.67	soft solid
Admixing hardened peanut oil with coconut oil				
3%—hardened	16.44	55.5–62	9.53	soft solid
2%—hardened	26.13	46–53	12.77	60% solid
1%—hardened	35.79	37–42.5	16.07	40% solid
Admixing hard kapok oil with coconut oil				
4%—hardened	25.40	49–56.5	12.48	30% solid
3%—hardened	45.13	31–38.5	19.09	35% solid

TABLE 9

Iodine values and melting points of some vegetable lards produced commercially

VEGETABLE LARDS	IODINE VALUES	MELTING POINTS
		°C.
Crisco	9.36	38.5–47
Kream Krisp	97.00	45.5
Pepang	12.17	37.5–45.5
Purico	8.58	39–48
Sampaguita	10.90	38.46
Snowdrift	89.00	44.10
Vi-va	9.10	38–46.5
Coconut-Pilinut	11	45–52
Coconut-Peanut	14	43.5–50
Coconut-Kapok	19	37–44

PROTEIN SUPPLEMENTS IN POULTRY RATIONS: X. FURTHER STUDIES ON THE INFLUENCE OF THE ADDITION OF COPRA MEAL IN RATIONS FOR GROWING CHICKS

JOSÉ G. LUNA

In a paper published recently, it was reported that a chick mash consisting of 56.25 parts by weight of rice bran, 18.75, ground corn (ratio 3:1), supplemented with 20, fish meal and 5, copra meal was slightly better than one in which 25 parts of fish meal were used alone as a supplement (Eamilao, 1938). Inasmuch as copra meal is cheaper and more readily available than the animal protein supplements now commonly used in poultry feeding, it is necessary, for the sake of economy, that further studies to determine definitely the influence on growing chicks of a combination of five per cent copra meal with twenty per cent of either shrimp meal or fish meal be carried out. These studies were, therefore, conducted in the Department of Animal Husbandry from November, 1935, to December, 1936.

Review of literature

Fronda, Badelles, and Padilla (1934) found that shrimp meal was not only the most palatable but also the most profitable protein supplement in rations for growing chicks. They also reported that fish meal, meat scraps, and tankage followed shrimp meal in palatability and cost of gain in the order named. Fronda and Kabigting (1935) reported that 25 per cent shrimp meal in the ration is the optimum amount for growing chicks.

Dalid (1935) found in his study on the influence of various kinds of fish meal in rations for chicks that 25 per cent protein supplement, either the "M.S.K. black" fish meal or the "Lighthouse" fish meal might be used satisfactorily as a substitute for shrimp meal. Rodriguez (1936), in a study to determine the optimum amount of tuna fish meal to feed to growing chicks, reported that 30 per cent tuna fish meal in the ration was the optimum amount to feed to growing chicks.

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[1] Experiment Station contribution No. 1312. Prepared in the Department of Animal Husbandry under the direction of Associate Professor F. M. Fronda.

Fronda and Mallonga (1935) reported that copra meal cannot be considered a good source of proteins for growing chicks, and that if it is used at all, it should not form more than 15 to 20 per cent of the total ration. Eamilao (1938) found that, of the different combinations of fish meal and copra meal that he tested, the combination which contained 20 per cent fish meal and 5 per cent copra meal was observed to be the best. This combined supplement even produced better results than the supplement of fish meal alone.

PLAN OF THE STUDY

Los Baños Cantonese chicks, artificially hatched from eggs collected from the Los Baños Cantonese flocks of the College, were used.

There were three sets of experiments made, each set covering a period of three months. The first set of 164 chicks, divided into four lots of 41 chicks each, was started on December 14, 1935, and closed on March 7, 1936. The second set of 300 chicks, divided into four lots of 75 chicks each, was started on March 7, 1936, and closed on May 30, 1936. The third set of 192 chicks was started on August 16, 1936, and closed on November 8, 1936. These chicks were divided into four lots of 48 chicks each.

The chicks were all raised in fireless brooders. Each lot was placed in individual outdoor brooding quarters on a grassy range. The feeds used were rice bran, corn meal, copra meal, "Lighthouse" fish meal, and shrimp meal.

The composition of the four rations tested were as follows:

FEEDS	LOT I	LOT II	LOT III	LOT IV
	kgm.	*kgm.*	*kgm.*	*kgm.*
Rice bran	56.25	56.25	56.25	56.25
Corn meal	18.75	18.75	18.75	18.75
Shrimp meal	25.00	20.00	—	—
Fish meal	—	—	25.00	20.00
Copra meal	—	5.00	—	5.00
Nutritive ratio 1: (based on chemical composition)	3.01	3.31	2.78	3.08

Both the rations for lots I and III are the standard chick rations used in the College. Ration No. 1 (lot I) was modified by replacing 5 parts of shrimp meal with an equal amount of copra meal. In ration No. 2 (lot III), 5 parts of fish meal were replaced by a similar amount of copra meal.

The rations were given in the form of dry mash which was placed in wooden feeding troughs kept open to the chicks during the day. Fresh water supplied in bamboo drinking troughs was always available.

The chicks were weighed individually soon after the different lots were formed and every week thereafter until they were twelve weeks old when the observations were stopped. The amount of feeds consumed and the mortality of the chicks in each lot were recorded. Other minor observations were made and also recorded.

RESULTS AND DISCUSSION

Growth of chicks. The weekly weight of the chicks was used as the criterion in determining the influence of the rations on the rate of growth. The average weekly weights of the different lots are given in table 1. It may be seen that the initial weights of the chicks in all the lots were practically the same. In general, from the first week through the fourth week, there was no appreciable difference in the rate of growth of the chicks in the different lots. After this period, however, and until the twelfth week, the rate of growth varied in all the lots studied. At the end of twelve weeks, the chicks in lot II weighed the most, and those of lot III, the least.

In all three trials, the superiority of lot II to lot I remained constant from the beginning of the experiment to the end of twelve weeks. Similarly, lot IV was consistently better than lot III from the third up to the twelfth week. By comparison of lots I and II, the difference was found statistically significant, 39.9 ± 10.533 grams. Similarly, between lot I and lot III, the difference, 41.2 ± 11.187 grams, was statistically significant. By comparison of lots III and IV, the difference was only 22.1 ± 10.921 grams and was found insignificant although the slight difference was in favor of lot IV, as shown by the relatively heavier average weight of the chicks.

It would be of interest to know why the rations in lot II and lot IV, which consisted of 20 per cent animal protein and 5 per cent copra meal supplements, should give better results in promoting the growth of chicks than those in lot I and lot III, which contained 25 per cent animal protein supplements alone. According to Henry and Morrison (1929), no feed is balanced in composition; that is, it does not contain all the necessary nutrients in the proportion needed by animals. It is evident that a larger variety of feeds may, by the law of chance, furnish a better combination of nutrients than one feed or two feeds alone. The reason is that when a variety of feeds is used, any deficiency in one feed may be partly supplemented by another. In this case, it is probable that the lot receiving the supplemental proteins from 20 per cent shrimp meal and 5 per cent copra meal, and from 20 per cent fish meal and 5 per cent copra meal was better than the lot receiving the protein supplement alone. These results corroborate the observations of Eamilao (1938).

Mortality. The percentage of mortality in the first, second, and third sets and the averages are presented in table 2. It may be seen that lot II had the lowest mortality of all the lots except in the first set, with only 18.84 ± 0.042 per cent. Lot III had the highest mortality, with an average for the three sets of 35.88 ± 0.055 per cent. It may be observed from this table that the lots with 5 per cent copra meal had lower averages of mortality than those fed with either shrimp meal or fish meal alone as supplements. This result was probably due to the better combination of the different nutrients, notably proteins, in the rations containing 5 per cent copra meal.

The mortality of lot III of 35.88 ± 0.055 per cent and that of lot IV of 28.50 ± 0.059 per cent compare favorably with the observations of Eamilao (1938), who reported a mortality of 29.8 ± 11.599 per cent for his lot fed with 25 per cent fish meal and 26.1 ± 2.006 per cent for his lot fed with 20 per cent fish meal and 5 parts copra meal. Dalid (1935) reported a mortality of 32.48 ± 2.918 per cent for his lot fed with 25 per cent "Lighthouse" fish meal. Fronda and Kabigting (1935) reported that the mortality of their lot fed with 25 per cent shrimp meal was 16.99 ± 2.172 per cent, which is a little less than that found in this study. The difference may be due to differences in the environmental conditions when the observations were made. During the course of this study, two storms occurred and rainfall was relatively heavy. There were no storms and less rainfall when Fronda and Kabigting carried on their experiment.

Amount of feeds consumed. It may be seen in table 3 that lot I consumed the most feed, followed in order by lots II, III, and IV. With the amount of feeds consumed per chick during the brooding period as the criterion for determining palatability, the ration of lot I was the most palatable followed by lots II, III, and IV in the order named. Thus, it may be stated that the replacement of five parts of the animal protein supplement with a similar amount of copra meal in two standard rations used in this study made the rations slightly less palatable. According to Amon (1930), in his experiment on the free choice of poultry feeds, the least consumed was copra meal.

From table 3, it may be observed also that the chicks in the lots in which the shrimp meal was used (lots I and II) consumed more feed than those of the fish meal lots (lots III and IV). This result agrees with that observed by Fronda, Badelles, and Padilla (1934), who reported that shrimp meal was superior to fish meal in palatability.

Returns above the cost of feeds. On the basis of current prices of the feeds, it was found that the ration of lot I cost ₱7.38 per 100 kilograms; that of lot II, ₱6.77; that of lot III, ₱6.08; and that of lot IV, ₱5.73. It will be seen, therefore, that by replacing 5 parts of either shrimp meal or fish meal with an equal amount of copra meal, the cost of the ration was reduced by ₱0.61 in the case of shrimp meal and by ₱0.35 in the case of fish meal for every 100 kilograms of the ration.

The returns above feed cost in the different lots, computed by subtracting the cost of feed from the value of all the birds that may be produced from 100 chicks calculated at ₱0.60 a kilogram live weight, are shown also in table 3. It can be seen in this table that lot II gave the largest return, ₱20.10, and lot III, the smallest, ₱13.93. The other lots were intermediate. It may also be noted in this table that the lots that did not have copra meal had lower returns above feed cost than the combination lots. This should be so, not only because of the superior results obtained with the use of the combined feeds, but also because of the higher cost of either shrimp meal or fish meal than of copra meal.

SUMMARY AND CONCLUSIONS

From the results obtained in these studies, the following summary may be presented:

1. The combination of 20 per cent shrimp meal and 5 per cent copra meal as the protein supplement in a ration for growing chicks was slightly superior to 25 per cent shrimp meal as the sole protein supplement.

2. The combination of 20 per cent fish meal and 5 per cent copra meal as the protein supplement in a ration for growing chicks was slightly superior to 25 per cent fish meal as the sole protein supplement.

3. The lowest mortality was recorded in lot II (20 per cent shrimp meal and 5 per cent copra meal), 18.84 ± 0.0425 per cent, and the highest, in lot III (25 per cent fish meal), 35.88 ± 0.0553 per cent.

4. The chick mashes containing shrimp meal and fish meal as the sole protein supplements were slightly more palatable than those wherein copra meal replaced part of the animal protein supplement.

5. The highest returns above feed cost were obtained from lot II (20 per cent shrimp meal and 5 per cent copra meal) and the lowest from lot III (25 per cent fish meal).

6. The lots containing no copra meal in the ration had lower returns above feed cost than those that contained copra meal.

7. Replacing 5 parts of either shrimp meal or fish meal with an equal amount of copra meal reduced the cost of the feed, produced heavier chicks, and resulted in lower mortality than when either shrimp meal or fish meal was used alone as supplement in rations for growing chicks.

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TABLE 1

Mean weekly weights of the chicks in the different lots for twelve weeks

AGE OF CHICKS	LOT I 25% SHRIMP MEAL		LOT II 20% SHRIMP MEAL, 5% COPRA MEAL		LOT III 25% FISH MEAL		LOT IV 20% FISH MEAL, 5% COPRA MEAL	
	No. of chicks	Mean weights	No. of chicks	Mean weights	No. of chicks	Mean weights	No. of chicks	Mean weights
		grams		*grams*		*grams*		*grams*
1 day old	164	27.1 ± 0.152	164	27.3 ± 0.161	164	27.5 ± 0.174	164	27.4 ± 0.183
1 week	160	36.2 ± 0.332	158	36.6 ± 0.094	143	35.9 ± 0.911	144	35.7 ± 0.121
2 weeks	153	52.2 ± 0.612	147	56.1 ± 0.514	135	51.8 ± 0.668	135	50.8 ± 0.539
3 "	152	69.9 ± 0.669	140	73.4 ± 0.734	127	68.3 ± 1.012	129	69.4 ± 0.786
4 "	145	92.2 ± 1.201	135	93.3 ± 1.142	120	90.1 ± 1.403	126	91.1 ± 1.226
5 "	138	129.8 ± 2.008	134	135.9 ± 2.002	115	127.6 ± 2.016	125	127.7 ± 1.672
6 "	131	174.8 ± 2.791	133	183.2 ± 2.863	115	164.6 ± 2.572	125	170.5 ± 2.403
7 "	130	224.6 ± 3.188	133	234.9 ± 3.311	112	220.2 ± 3.439	124	223.9 ± 3.103
8 "	127	284.6 ± 3.801	133	304.2 ± 3.911	111	273.1 ± 4.109	122	280.9 ± 4.318
9 "	125	383.9 ± 4.651	132	392.9 ± 4.378	110	352.7 ± 3.958	119	365.5 ± 4.664
10 "	125	466.5 ± 6.011	131	477.3 ± 6.005	107	426.3 ± 6.555	119	448.6 ± 6.144
11 "	125	526.9 ± 7.488	131	547.6 ± 6.528	107	486.9 ± 7.481	117	502.2 ± 6.984
12 "	125	588.5 ± 7.745	131	628.4 ± 7.357	107	547.3 ± 8.074	117	569.4 ± 7.024

TABLE 2

Percentage of mortality of the chicks during the twelve weeks of brooding

LOT NO.	SET			AVERAGE
	1st	2nd	3rd	
	per cent	*per cent*	*per cent*	*per cent*
I	14.63	26.66	27.08	22.79 ± 2.610
II	17.78	20.00	18.75	18.84 ± 0.042
III	34.14	36.00	37.50	35.88 ± 0.055
IV	26.82	29.33	29.37	28.50 ± 0.059

TABLE 3

Amount of feeds consumed and returns above feed costs based on 100 chicks at the start

LOT NO.	I	II	III	IV
Supplement used	25% shrimp meal	20% shrimp meal, 5% copra meal	25% fish meal	20% fish meal, 5% copra meal
No. of chicks	100	100	100	100
No. of weanlings raised	77	81	64	71
Average weight, gm.	589	628	547	569
Total weight, kgm.	45.35	50.87	35.01	40.40
Value of chickens @ 60¢ a kgm., pesos	27.21	30.52	21.01	24.24
Average feed consumed, kgm.	1.97	1.90	1.82	1.72
Total feed consumed, kgm.	151.7	153.9	116.5	122.1
Cost of feed per kgm., centavos	7.38	6.77	6.08	5.73
Total cost of feed, pesos	11.19	10.42	7.08	7.00
Returns above cost of feed, pesos	16.02	20.10	13.93	17.24

COLLEGE AND ALUMNI NOTES

Dr. Leon G. Gonzalez, accompanied by Mrs. Gonzalez, returned on May 27 from an extended official trip to Java where he studied agricultural conditions and observed the operation of agricultural experiment stations. He brought back a large collection of seeds and planting materials.

Enrollment in the College in June was 520 as compared with 477 last year.

Recent promotions at the College of Agriculture include Dr. Valente Villegas from assistant head to head of the Department of Animal Husbandry, Dr. Arturo B. Rotor from acting director to director of the U. P. Los Baños Infirmary, Dr. Pablo N. Mabbun from instructor to assistant professor of agricultural economics, and Mr. Martin S. Celino from graduate assistant to instructor in plant pathology.

The first meeting of the College faculty was held on June 12 with President B. M. Gonzalez in attendance. At the request of Dean Uichanco, the president made a few remarks. Among other things, the faculty approved the graduation of the following:

Bachelor of Science in Agriculture

1. Tomas G. Cabotage
2. William Crocker
3. Domingo V. Fermin
4. Bhakdi Lusanandana
5. Felix B. Robles
6. Ramon Samaniego

Bachelor of Science in Sugar Technology

1. Amando E. Libunao

Mr. Santiago R. Cruz, Philippine Government pensionado at Cornell University, writes Dr. A. L. Teodoro that, on June 19, 1939, he obtained the degree of M.Sc. in Agriculture with a major in agricultural engineering.

Dr. I. J. Brugmans, Secretary of the Department of Public Education, Batavia, Java, accompanied by Dr. W. Huender, Consul

General of the Netherlands, Manila, was a campus visitor on June 23. Dr. Brugmans visited some of the departments of the College and secured information in connection with his survey of university administration and operation in the Philippines.

Sponsored by the College committee on drama and music, "Melody Night" was presented to the public at Baker Hall on July 3, 1939, at 7:30 in the evening. Amateur talent from the College constituency presented dances and songs characteristic of their different regions of the Philippines as well as of China, Siam, and Java.

The following papers were read and discussed at the meeting of the Los Baños Biological Club on June 29, 1939:

Dr. Valente Villegas. The birth weights of horses, cattle, and carabaos and their relation to the weights of dams.

Dr. Rafael B. Espino. Studies on the fertilizing value of Mayon Volcano ash: II. Beneficial effects of adding ammonium sulfate.

On July 14, 1939, the following students of the College of Agriculture, class of 1939, were among those initiated as members of the Honor Society of Phi Kappa Phi, University of the Philippines Chapter:

Eugenio A. Alcasid
Severino Hermosura
Ian Khambanonda
Victor U. Luis
Isidro S. Macaspac
Ambrosio L. Madamba
Manuel V. Quisumbing
Dioscorro L. Umali
Bhakdi Lusanandana

In the election of officers of the Society at the same meeting, Dean Uichanco was elected Vice-President for the academic year, 1939-1940.

THE BIRTH WEIGHTS OF HORSES, CATTLE, AND CARABAOS AND THEIR RELATION TO THE WEIGHTS OF DAM [1]

VALENTE VILLEGAS
Of the Department of Animal Husbandry

The need for norms of birth weights of farm animals raised in the Philippines is evident. Similarly, the relation between the birth weights of such animals and the weights of their dams is considered important. Hence, the study presented in this paper was undertaken.

The object of this investigation was to determine the birth weights of Philippine horses, Philippine cattle, Nellore cattle, Red Scindi cattle, Philippine carabaos, and Indian buffaloes and the ratio of such birth weights to the weights of their dams.

The work was undertaken in the Department of Animal Husbandry, College of Agriculture, from July 31, 1917, to November 1, 1938.

Animals

In this study, 22 horses (10 of native blood and 12 American and Arab grades), 17 Philippine cattle, 45 Nellore cattle, 14 Red Scindi cattle, 34 Philippine carabaos, and 41 Indian buffaloes were used. Of the horses, 12 were males and 10 were females; of Philippine cattle, 7 were males and 10 were females; of Nellore cattle, 22 were males and 23 were females; of Red Scindi cattle, 8 were males and 6 were females; of Philippine carabaos, 16 were males and 18 were females; and of Indian buffaloes, 27 were males and 14 were females.

Of the Philippine carabaos, 21 were sired by an Indo-Chinese carabao bull. The Indo-Chinese carabao differs from the native animal in certain minor features, both belonging to the same breed.

Management

The mares were either kept loose in paddocks, or tethered in the pasture during the day and put in box stalls at night. As a rule, a concentrate consisting of five parts, by weight, of rice bran,

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[1] Experiment Station contribution No. 1313. Read before the Los Baños Biological Club on June 29, 1939.

THE PHILIPPINE AGRICULTURIST, VOL. XXVIII, No. 4, SEPTEMBER, 1939.

three parts of corn, and two parts of copra meal was given to them in the evening at the rate of one per cent of their live weight. Fresh forage like corn fodder, guinea grass, or tapilan was supplied to them at night. Each mare was bred by the stallion at oestral period.

The Philippine and Nellore cattle were treated as range animals. They were allowed to graze in open pastures at all times, supplementary feeds like silage and rice straw were given to them during the dry season when the pasture was poor. A ratio of one bull for every 25 cows or less was maintained to insure the breeding of all non-gravid females.

All female Philippine carabaos and Indian buffaloes were kept in the dairy herd for milking purposes. They obtained their feed from the pasture during the night and between milking times during the day. Silage was also supplied to them in the barn as supplementary feed. Milking was done in the barn either in the morning or in the afternoon. The calves were separated from their dams twelve hours before milking time. A separate pasture was used for the growing heifers. In both the dairy and heifer herds, male carabaos were put to breed all non-gravid females.

The Red Scindi cows, being more valuable and being high milk producing animals, received greater attention. They were placed separately in box stalls in the afternoon and at night. In the morning they were allowed to graze in the pasture. Milking was done three times a day, at 5:00 a.m., 11:00 a.m., and 4:00 p.m. The calves were separated from them three days after delivery and fed artificially with cow's milk. The cows were fed in the morning, and evening a concentrate mixture consisting of twenty-five parts by weight each of rice bran and ground corn, twenty-one parts of copra meal, one part of fish meal, and one and one-half parts of common table salt, each cow receiving from two to three kilograms of the mixture a day. Guinea, guatemala, or napier grass was supplied as soilage. Breeding was done by bringing the bull to the cow that was observed to be in heat.

Birth weights

Horses. For the purpose of obtaining the relationship between the birth weight of foals and the weight of their dam, the birth weights of either sex and those of combined sexes are presented in tables 1 and 2, respectively. The mean birth weight of native foals of both sexes was 28.10 ± 0.70 kgm., the range being from 22.7 to 32.6 kgm.

Native cattle. The mean birth weight of male native calves was 19.06 ± 0.66 kgm., and that of females, 18.32 ± 0.78 kgm., there being no significant difference between the two means. The range in the weight of the male calves was from 13.6 to 22.6 kgm. and that of the females from 11.7 to 22.6 kgm. The mean birth weight of calves of combined sexes was 18.62 ± 0.56 kgm.

Nellore cattle. In the Nellore breed, the birth weights of the male calves gave a mean of 24.39 ± 0.44 kgm. and those of the females, 23.61 ± 0.28 kgm., the difference between the means being insignificant. The birth weights of the males varied from 13.6 to 31.7 kgm. and those of the females from 17.2 to 29.4 kgm. The mean of the birth weights of the combined sexes was 23.92 ± 0.26 kgm. Littlewood [2] gives the average birth weight of bull calves of this breed as 29.7 kgm. and that of the heifer calves 27.2 kgm., the maximum being 35.8 kgm. with the males and 38.1 kgm. with the females.

Red Scindi cattle. Among the calves of the Red Scindi cattle, the mean birth weight of the males was 26.44 ± 0.87 kgm. and that of the females 24.60 ± 0.77 kgm. with no significant difference between them. The range was from 22.6 to 31.7 kgm. in the males and from 21.7 to 29.0 kgm. in the females. The mean birth weight of both sexes was 25.65 ± 0.60 kgm. According to Littlewood [2], the average birth weight of bull calves of the breed is 21.3 kgm. and that of the heifer calves 19.0 kgm.

Native carabaos. The birth weights of male calves of native carabaos had a mean of 32.20 ± 1.27 kgm. and those of the females, 31.30 ± 0.99 kgm. The difference between the two means is insignificant. The variation in the birth weights among the male calves was from 18.1 to 49.8 kgm. and among the females from 20.0 to 50.7 kgm. The mean birth weight of calves of combined sexes was 31.95 ± 0.78 kgm. Levine's [3] figures for the young of Chinese carabaos which are supposed to belong to the same breed as the Philippine animals are from 27.3 to 36.4 kgm. at birth. In a subsequent paper by the same author,[4] the average birth weight of 10 bull calves of the same breed is 31 kgm. and that of the heifer calves 30 kgm.

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[2] LITTLEWOOD, CAPT. R. W. 1936. Live stock of Southern India. viii + 239 p., 141 fig. Madras: Superintendent, Government Press.

[3] LEVINE, C. O. 1920. Water buffaloes—a tropical source of butterfat. Journal of Dairy Science 3: 340–352.

[4] LEVINE, C. O. 1923. Water buffaloes for dairy purposes. International Research in the Science and Practice of Agriculture 1: 734–735.

Indian buffaloes. The mean birth weight of Indian buffalo male calves was 34.12 ± 0.68 kgm. and that of the females 34.02 ± 0.69 kgm., there being no significant difference between the two means. The minimum weight of male calves was 24.0 kgm. while the maximum was 43.5 kgm.; the female calves had a minimum weight of 27.2 kgm. and a maximum weight of 42.1 kgm. The mean birth weight of all male and female calves was 34.08 ± 0.52 kgm.

While the difference between the means of the birth weights of the males and females in large animals was not significant, it is interesting to note that the mean birth weights of the males were consistently greater than those of the females.

Relation between birth weight and weight of dam

Horses. The ratio of birth weight of colts to the weight of their dam, as shown in table 1, was 10.33 ± 0.19 per cent, and 9.60 ± 0.60 per cent in the case of fillies, with no significant difference between the two means. The ratio in foals of both sexes, as may be seen in table 2, was 10.29 ± 0.27 per cent, the range being from 6.17 to 14.75 per cent. With native horses of both sexes the ratio was 11.39 ± 0.54 per cent, the range being from 8.96 to 14.75 per cent.

Native cattle. In native cattle, the ratio in the males was 7.63 ± 1.19 per cent and in the females, 7.14 ± 0.30 per cent, the difference between the means being insignificant. Combining the birth weights of calves of the two sexes, the ratio was found to be 7.34 ± 0.23 per cent, the range being from 4.39 to 9.25 per cent.

Nellore cattle. The male calves of this breed had a ratio of 7.41 ± 0.24 per cent while that of the females was 7.55 ± 0.20 per cent, there being no significant difference between the means. Calves of both sexes gave a ratio of 7.48 ± 0.15 per cent, the fluctuation being from 4.13 to 10.95 per cent. From the average weights of the cows, ranging from 408 to 454 kilograms, as reported by Littlewood[5], the ratio of the birth weight of male calves to the weight of the dam is from 6.54 to 7.28 per cent and that of the female calves from 5.94 to 6.66 per cent.

Red Scindi cattle. The ratio in male Red Scindi calves was 7.17 ± 0.25 per cent and in the females 6.45 ± 1.22 per cent, the difference between the means being insignificant. With calves of both sexes, the ratio was 6.86 ± 0.22 per cent, the variation being from 5.27 to 9.00 per cent. Basing calculations on the average weights of cows of this breed, as given by Littlewood [6], varying from 295 to 340 kilograms, the relation of the birth weight of male calves to the weight of their dams was from 6.26 to 7.22 per cent and that of the female calves from 5.58 to 6.44 per cent.

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[5] LITTLEWOOD, CAPT. R. W., *op. cit.*

Native carabaos. In the male young of native carabaos, the ratio was 6.58 ± 0.21 per cent, while in the females it was 6.64 ± 0.20 per cent, the difference between the two means being insignificant. Native carabao calves of both sexes showed a ratio of 6.61 ± 0.14 per cent, the range being from 4.19 to 9.53 per cent.

Indian buffaloes. The ratio in male Indian buffalo calves was 6.22 ± 0.14 per cent and in the females 6.16 ± 0.12 per cent. The difference between the means is insignificant. With both sexes considered, the ratio was 6.20 ± 0.20 per cent, the range being from 4.46 to 9.05 per cent.

Owing to the higher birth weights of the males as compared with those of the females, the ratio of birth weights to the weights of dams was consistently higher in the males than in the females, except in the Nellore cattle, even though the difference between the ratio of birth weights to the weights of dams of the two sexes was significant.

SUMMARY

1. The mean birth weights of male and female offspring of large farm animals raised in the Philippines are as follows:

	MALE *kgm.*	FEMALE *kgm.*
Native ox	19.06 ± 0.66	18.32 ± 0.78
Nellore ox	24.39 ± 0.44	23.61 ± 0.28
Red Scindi ox	26.44 ± 0.87	24.60 ± 0.77
Native carabao	32.20 ± 1.27	31.30 ± 0.99
Indian buffalo	34.12 ± 0.68	34.02 ± 0.69

2. Combining both sexes, the mean birth weights of large farm animals follow:

	Kgm.
Philippine horse	28.10 ± 0.70
Native ox	18.62 ± 0.56
Nellore ox	23.92 ± 0.26
Red Scindi ox	25.65 ± 0.60
Native carabao	31.95 ± 0.78
Indian buffalo	34.08 ± 0.52

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[6] LITTLEWOOD, CAPT. R. W., *op. cit.*

3. The ratios of birth weight to the weight of dam in male and female young of large farm animals follow:

	MALES *per cent*	FEMALES *per cent*
Horse	10.33 ± 0.19	9.60 ± 0.60
Native ox	7.63 ± 1.19	7.14 ± 0.30
Nellore ox	7.41 ± 0.24	7.55 ± 0.20
Red Scindi ox	7.17 ± 0.25	6.45 ± 1.22
Native carabao	6.58 ± 0.21	6.64 ± 0.20
Indian buffalo	6.22 ± 0.14	6.16 ± 0.12

4. With the male and female offspring taken together, the ratios of birth weight to the weight of dam of large farm animals are as follows:

	Per cent
Native horse	11.39 ± 0.54
Native ox	7.34 ± 0.23
Nellore ox	7.48 ± 0.15
Red Scindi ox	6.86 ± 0.22
Native carabao	6.61 ± 0.14
Indian buffalo	6.20 ± 0.20

5. The difference between the means of birth weights of male and female offspring and the corresponding ratios of such birth weights to the weights of dams in large farm animals is not significant. However, the males were consistently heavier at birth and, except in the Nellore cattle, had higher ratios to the weights of dam than the females.

TABLE 1

Birth weight of horses, cattle, and carabaos of either sex and its relation to weight of dam

CLASSES OF ANIMALS	BIRTH WEIGHT			
	Range		Mean	
	Males	Females	Males	Females
	kgm.	*kgm.*	*kgm.*	*kgm.*
Horses	20.9 — 37.2	18.1 — 39.0	29.35 ± 0.92	25.57 ± 0.92
Native cattle ...	13.6 — 22.6	11.7 — 22.6	19.06 ± 0.66	18.32 ± 0.78
Nellore cattle ...	13.6 — 31.7	17.2 — 29.4	24.39 ± 0.44	23.61 ± 0.28
Red Scindi cattle	22.6 — 31.7	21.7 — 29.0	26.44 ± 0.87	24.60 ± 0.77
Native carabaos.	18.1 — 49.8	20.0 — 50.7	32.20 ± 1.27	31.30 ± 0.99
Indian buffaloes.	24.0 — 43.5	27.2 — 42.1	34.12 ± 0.68	34.02 ± 0.69

TABLE 1 (continued)

CLASSES OF ANIMALS	RELATION OF BIRTH WEIGHT TO WEIGHT OF DAM			
	Range		Mean	
	Males	Females	Males	Females
	per cent	*per cent*	*per cent*	*per cent*
Horses	8.96 — 11.86	6.17 — 14.75	10.33 ± 0.19	9.60 ± 0.60
Native cattle ...	5.28 — 9.25	4.39 — 8.52	7.63 ± 1.19	7.14 ± 0.30
Nellore cattle ...	4.13 — 10.82	4.32 — 10.95	7.41 ± 0.24	7.55 ± 0.20
Red Scindi cattle	5.27 — 8.63	5.40 — 9.00	7.17 ± 0.25	6.45 ± 1.22
Native carabaos.	4.19 — 8.83	4.21 — 9.53	6.58 ± 0.21	6.64 ± 0.20
Indian buffaloes.	4.46 — 9.05	5.31 — 7.36	6.22 ± 0.14	6.16 ± 0.12

TABLE 2

Birth weight of horses, cattle, and carabaos of combined sexes and its relation to the weight of dam

CLASSES OF ANIMALS	BIRTH WEIGHT		RELATION OF BIRTH WEIGHT TO WEIGHT OF DAM	
	Range	Mean	Range	Mean
	kgm.	*kgm.*	*per cent*	*per cent*
Horses	18.1 — 39.0	28.69 ± 0.77	6.17 — 14.75	10.29 ± 0.27
Native cattle ...	11.7 — 22.6	18.62 ± 0.56	4.39 — 9.25	7.34 ± 0.23
Nellore cattle ..	13.6 — 31.7	23.92 ± 0.26	4.13 — 10.95	7.48 ± 0.15
Red Scindi cattle	21.7 — 31.7	25.65 ± 0.60	5.27 — 9.00	6.86 ± 0.22
Native carabaos.	18.1 — 50.7	31.95 ± 0.78	4.19 — 9.53	6.61 ± 0.14
Indian buffaloes.	24.0 — 43.5	34.08 ± 0.52	4.46 — 9.05	6.20 ± 0.20

STUDIES ON THE FERTILIZING VALUE OF MAYON VOLCANO ASH: II. BENEFICIAL EFFECTS OF ADDING AMMONIUM SULFATE[1]

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Of the Department of Agricultural Botany

WITH SIX TEXT FIGURES

The stunted growth and chlorotic leaves of certain young plants grown in Lipa clay loam to which had been added in varying amounts relatively large quantities of Mayon Volcano ash led the writer (Espino, 1939) to suspect two main causes: (*a*) production in the soil of a physiologically unbalanced solution, and (*b*) production of a too compact soil which is consequently poorly drained and inadequately aërated. The present study was undertaken with the objects of determining the correctness or incorrectness of these suppositions.

This study was conducted in the experimental yard of the Department of Agricultural Botany. The cultures of radish, soybean, rice, and corn were started on October 31, 1938; those on tomato, a little later. My student assistants, Messrs. Esteban Castillo and Saturnino Posadas, helped in conducting the cultures.

MATERIALS, METHODS, AND RESULTS

The cultures. The culture media consisted mainly of a certain amount of Lipa clay loam to which was added Mayon Volcano ash in varying quantities (table A).

TABLE A
The culture media employed[a]

CULTURE NO.	MIXTURES OF LIPA CLAY LOAM AND MAYON VOLCANO ASH
I	Control: soil alone, 5 kgm. air-dry
II	½ soil + ½ ash by volume, 3.5 kgm. soil + 4.3 kgm. ash
III	5 kgm. soil + ash 1 cm. thick, or 417 gm.
IV	5 kgm. soil + ash 2 cm. thick, or 834 gm.
V	5 kgm. soil + ash 4 cm. thick, or 1668 gm.
VI	5 kgm. soil + ash 6 cm. thick, or 2502 gm.
VII	5 kgm. soil + 2 gm. of ammonium sulfate

[a] To each of cultures II, III, IV, V, and VI two gm. of ammonium sulfate were added a few days after germination.

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[1] Experiment Station contribution No. 1314. Read before the Los Baños Biological Club on June 29, 1939.

Radish, soybean, rice, and corn grown from seeds were again used as indicators. These plants were grown separately in four sets of cultures and each set consisted of seven triplicate cultures. All the cultures that received the volcanic ash also received an equal amount of ammonium sulfate, two grams to each pot. The fertilizer was added so as to increase the nitrogen content of the soil.

Two additional sets of culture media were prepared, to which tomato seedlings were transplanted on December 5, 1938. On December 17, 1938, cultures II to VI in one set were each fertilized with two grams of sulfate of ammonia. Except VII, none of the cultures in the other set received the fertilizer. In these two sets of cultures, therefore, II to VI inclusive received liberal application of the volcanic ash in varying quantities. In one set, the nitrogen content of the soil was increased by the addition of two grams of ammonium sulfate per pot, and in the other set, the nitrogen content remained as it was, scantily present in the soil.

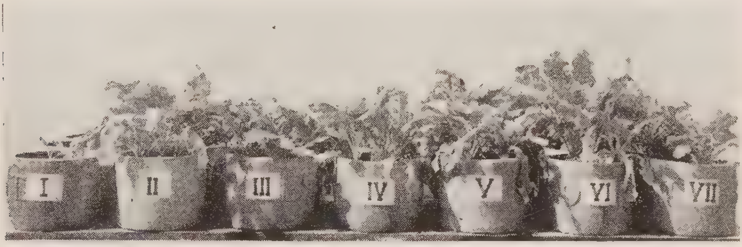

Fig. 1.—Radish plants grown in Lipa clay loam. To cultures II to VI, inclusive, were added varying liberal amounts of Mayon Volcano ash and 2 grams of ammonium sulfate fertilizer each. For exact treatments given, see table A.

Care of cultures. The cultures were exposed to sun and rain, and were frequently weeded and cultivated. As the experiments were conducted during November and December, 1938, and the early part of January, 1939, when frequent light rains fell, watering was seldom necessary.

Harvesting. On December 14, 1938, the radish, soybean, rice, and corn were harvested two days after they had been photographed (figs. 1, 2, 3 and 4). The average height of plants and the average green weight of tops, as relative values are given in tables 1 and

2, respectively.[2] The storage roots of radish were weighed (table 3). The tomato plants were photographed on January 17, 1939, (figs. 5 and 6), and harvested one day later. The data on height and green weight of tops of the plants that were fertilized with ammonium sulfate are also shown as relative values in tables 1 and 2, respectively.[3] To compare the unfertilized and the fertilized cultures of tomatoes, the data obtained are given in tables 4 and 5. In table 4 are given in relative values the data on height of plants and green weight of tops; while table 5 shows data on number of flowers and number and green weight of young fruits of tomatoes.

The H-ion concentration. In order to determine whether or not the injury to radish, soybean, rice, corn, and tomato, of the addition of large quantities of Mayon Volcano ash to Lipa clay loam was due to changes in soil reaction, the p^H values of the culture media, were determined. Samples of the soil media were collected by Mr. F. T. Pantaleon, of the Department of Agricultural Botany, from each culture type in the two sets of culture, the fertilized and the unfertilized; and with the coöperation of Dr. Nicolas L. Galvez of the Department of Soils two sets of tests were made, employing Trenel's acidometer. The results are given in table 6. Galvez (1939) reported that the Mayon Volcano ash he analyzed had a p^H value of 5.2.

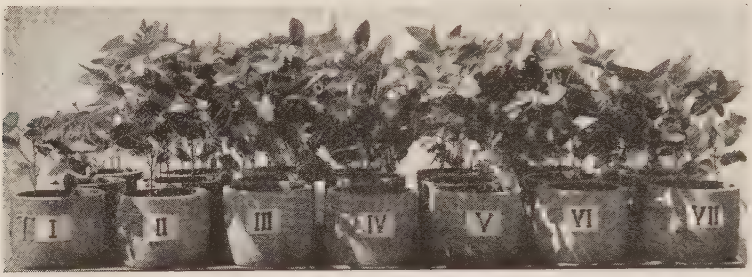

Fig. 2.—Soybean plants grown in Lipa clay loam. To cultures II to VI, inclusive, were added varying liberal amounts of Mayon Volcano ash and 2 grams of ammonium sulfate fertilizer each. For exact treatments given, see table A.

DISCUSSION OF RESULTS

The p^H values of culture media. Table 6 indicates that liberal application of Mayon ash made the culture media only slightly more

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[2, 3] The mass of original data is on file in the Department of Agricultural Botany.

acidic than the original Lipa clay loam used. It should be noted that the lowest p^H value of the volcanic ash-containing cultures was 5.75, which is by no means too acidic. Moreover, the soybean, a plant which cannot stand acid soil, was the least adversely affected by treatment with the Mayon ash. Hence, the main cause of the harmful effects observed must be sought elsewhere.

Effects of adding ammonium sulfate. The addition of two grams of sulfate of ammonia fertilizer per pot was equivalent to 570 kgm. per hectare. Judging from the stand of the plants and the intensity of the green of their leaves, this rate was enough for the normal growth and development of the species of plants when applied to Lipa clay loam. The plants were green (some even slightly dark green) and fairly well-developed (figs. 1, 2, 3, 4, and 6).

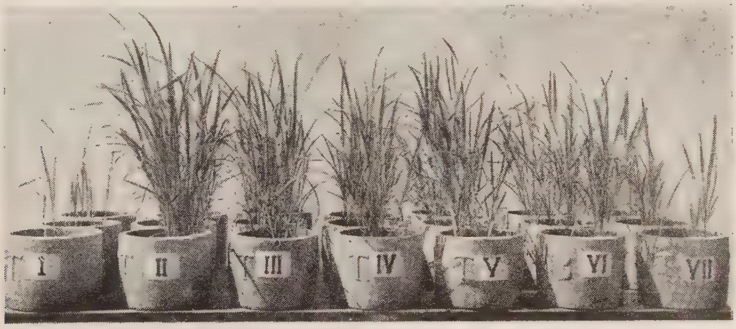

Fig. 3.—Rice plants grown in Lipa clay loam. To cultures II to VI, inclusive, were added varying liberal amounts of Mayon Volcano ash and 2 grams of ammonium sulfate fertilizer each. For exact treatments given, see table A.

The data on height and also on green weight of tops of the plants supplied with ammonium sulfate (tables 1, 2, and 4) show that culture I, which received no treatment and was employed as control, was the poorest in the lot. In these tables it may also be seen that culture VII, which contained Lipa clay loam and two grams of ammonium sulfate but no Mayon ash, was inferior to all of the ash-treated cultures in the lot. Moreover, among the cultures treated both with the volcanic ash and sulfate of ammonia (II to VI), the best results were obtained mostly from those which were supplied with relatively large amounts of Mayon ash. It appears, therefore, that the liberal application of Mayon Volcano ash to Lipa clay loam properly fertilized with ammonium sulfate produced radish, soybean, rice, corn, and tomato plants very well developed and much better than those grown either in Lipa clay loam only or in this soil supplied with the same amount of ammonium sulfate. It appears further that the harmful effects, that is, chlorotic plants with stunted growth previously observed and again seen with some cultures of tomatoes (table 4 fig. 5) to which relatively large amounts of Mayon ash had been added, disappeared entirely upon adding sulfate of ammonia to the soil, and the plants became healthy and well developed (fig. 6).

In table 3, culture I, the control, produced no storage roots of radish; VII, which was fertilized only with two grams of ammonium sulfate, developed rather small radish roots, while II to VI, inclusive, all produced storage roots, with II, V, and VI producing the most. It should be noted that cultures II to VI each received two grams of ammonium sulfate in addition to varying amounts of the volcanic ash, and if it had not been for the death of some of the radish plants in some cultures, the amount of edible radish roots produced might have been proportional to the amount of the Mayon Volcano ash used. Even with this slight discrepancy, however, the liberal application of Mayon ash with a correct amount of sulfate of ammonia to Lipa clay cloam was undoubtedly conducive to the formation and development of edible roots of radish.

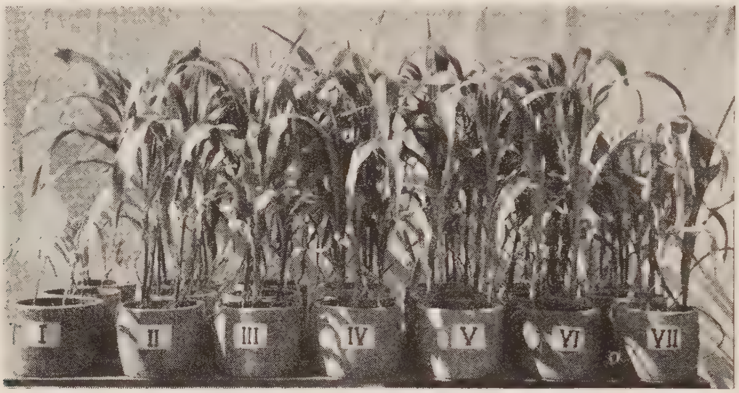

Fig. 4.—Corn plants grown in Lipa clay loam. To Cultures II to VI, inclusive, were added varying amounts of Mayon Volcano ash and 2 grams of ammonium sulfate fertilizer each. For exact treatments given, see table A.

The cultures that received volanic ash without ammonium sulfate (II to VI, table 5) produced even fewer flowers than did either

I, control, or VII, which was supplied with only two grams of fertilizer without Mayon ash. On the other hand, table 5 shows that in the ammonium sulfate-fertilized cultures, the production and development of flowers and fruits of tomato seemed favorably affected, provided these cultures were also supplied with the volcanic ash. The yields from I and VII, which received no Mayon ash at all, were much lower than those from any of the ash-treated cultures, provided 2 grams of ammonium sulfate had been added to the culture. It may be concluded, therefore, that adding liberal amounts of Mayon Volcano ash to Lipa clay loam when supplemented with sulfate of ammonia was conducive to production and rapid development of flowers and fruits of tomato. Without ammonium sulfate, the Mayon ash did not seem beneficial.

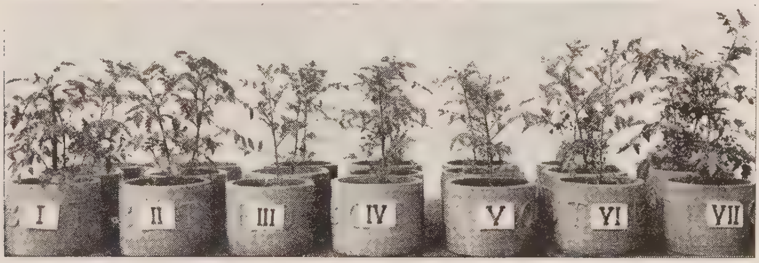

Fig. 5.—Tomato plants grown in Lipa clay loam. To cultures II to VI, inclusive, were added varying liberal amounts of Mayon Volcano ash; see table A. Culture I contained only Lipa clay loam, and to culture VII were added 2 grams of ammonium sulfate fertilizer.

Effect on soil texture. It was noted that the addition to Lipa clay loam of a liberal amount of Mayon ash produced a material change in the texture and porosity of the soil. The new soil appeared more compact, and consequently poorly drained and inadequately aërated. It might thus be suspected that compactness of the soil might be the cause of the deleterious effects. It appears, however, that irrespective of the rate of application of Mayon ash, the growth and development of all the five species of plants were better when ammonium sulfate was added with the volcanic ash to the soil than when the soil was treated only with Mayon ash. In most cases, the larger the amount of Mayon ash used the better was the growth and development of the plant. Therefore, compactness of the culture media could not be the real cause of the apparent deleterious effects observed.

The most probable cause. From the work of Galvez, Aquino, and Mamisao (1939), it appears that the addition of Mayon Volcano ash to Lipa clay loam appreciably increased the amounts of a number of inorganic constituents of the soil. As computed in table 7, the amounts of available, or citric acid-soluble P_2O_5 in Mayon ash added to different cultures amounted to from 50.4 to 514.1 kgm. per hectare, and the computed amounts of available, or citric acid-soluble, K_2O employed ranged from 15.6 to 159.1 kgm. per hectare. Thus, the addition of these plant food constituents to a soil which already had enough or almost enough of these substances, but was very poor in nitrogen, not only increased considerably its P_2O_5 and K_2O contents but apparently threw out the N-P_2O_5-K_2O balance considered good for the plants. As Willcox (1930) pointed out, "if the amount of one plant food is increased far out of proportion to one or more of the others, the (yield) curve ceases to rise, bends over", and the yield may thus again become zero.

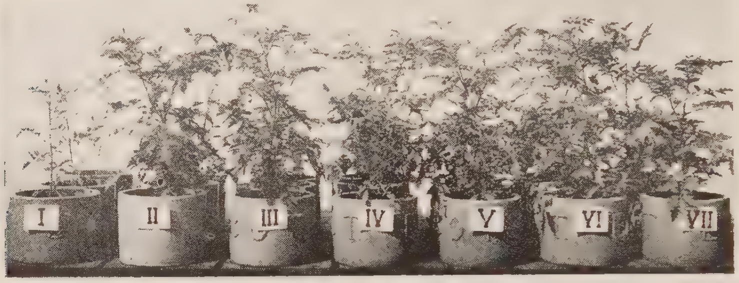

Fig. 6.—Tomato plants grown in Lipa clay loam. To cultures II to VI, inclusive, were added varying liberal amounts of Mayon Volcano ash and 2 grams of ammonium sulfate fertilizer each. For exact treatments given, see table A.

The harmful effects which appear to be due to the lack of a reasonably balanced nutrition when a liberal amount of Mayon ash was added to a soil low in nitrogen, disappeared when sufficient nitrogen as sulfate of ammonia was added. The addition of nitrogen apparently produced a fairly balanced solution in the soil which, in turn, produced well-developed plants much better than those grown in Lipa clay loam either alone or with ammonium sulfate but without volcanic ash.

From the results of this study it may be concluded that the Mayon Volcano ash is not toxic to plants, and it possesses mineral nutrients valuable to them when applied to a soil rich in nitrogen or to an unfertile soil when accompanied with a suitable amount of ammonium sulfate.

SUMMARY AND CONCLUSIONS

1. The Mayon Volcano ash used was of rather low fertility, especially because of absence of nitrogen.

2. The main cause of the harmful effects, that is, stunted growth and chlorotic leaves previously observed, could not be due to the low p^H value of the culture media.

3. The harmful effects upon plants not only disappeared with the addition of sulfate of ammonia to the culture but the plants became even more healthy and well developed.

4. A liberal addition of Mayon ash to Lipa clay loam supplemented with a correct amount of sulfate of ammonia was conducive to formation and development of edible roots of radish, and also favorable for the production and rapid development of flowers and fruits of tomato.

5. Compactness of soil in the culture media resulting from a liberal application of Mayon ash to Lipa clay loam could not be the real cause of the apparent deleterious effects observed.

6. Mayon Volcano ash is not poisonous to plants. It possesses mineral nutrients valuable to them when applied to a soil rich in nitrogen or when applied to an unfertile soil accompanied by a suitable amount of ammonium sulfate.

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TABLE 1

Average heights of the different plants, in relative values [a]

CULTURE NO.[b]	RADISH	SOYBEAN	RICE	CORN	TOMATO
I	100 (13.9 cm.)	100 (25.9 cm.)	100 (41.6 cm.)	100 (52.9 cm.)	100 (36.7 cm.)
II	226	177	170	216	142
III	216	173	158	205	155
IV	221	187	156	203	145
V	217	172	160	214	149
VI	227	151	151	206	159
VII	181	141	123	182	139

[a] Average data in culture I, control, arbitrarily taken as 100; the rest converted into relative values.

[b] Cultures II to VI, inclusive, treated with Mayon Volcano ash plus 2 grams of ammonium sulfate.

TABLE 2

Average green weights of tops of the different plants, in relative values

CULTURE NO.	RADISH	SOYBEAN	RICE	CORN	TOMATO
I	100 (8.7 gm.)	100 (16.2 gm.)	100 (5.3 gm.)	100 (12.3 gm.)	100 (16.0 gm.)
II	1472	364	773	193	628
III	944	324	534	183	491
IV	1202	381	487	189	610
V	1181	407	560	177	562
VI	1462	365	504	183	580
VII	847	271	251	137	454

TABLE 3

Weights of storage roots of radish produced

CULTURE NO.	WEIGHT OF STORAGE ROOTS			
	a	b	c	Total
	grams	*grams*	*grams*	*grams*
I	none [a]	none	none	1.0
II	34.0 [b]	40.0	66.0 [c]	140.0
III	21.0	12.5 [b]	34.0	67.5
IV	6.0 [d]	30.0	37.0	73.0
V	73.0 [c]	70.0	111.5	254.5
VI	55.0 [c]	56.5 [d]	132.0 [d]	243.5
VII	6.0	42.0	15.0	63.0

[a] *None* where only ordinary roots (not swollen) were present.

[b] Only one plant was big.

[c] One plant was small.

[d] Only two plants alive.

TABLE 4

Average data obtained from tomato plants grown in Lipa clay loam to which was added Mayon Volcano ash in varying amounts, and ammonium sulfate [a]

CULTURE NO.	UNFERTILIZED		FERTILIZED	
	Height of plants	Green weight of tops	Height of plants	Green weight of tops
I	100 (34.8 cm.)	100 [b] (25.2 gm.)	100 (26.7 cm.)	100 (16.0 gm)
II	96	155	142	628
III	78	89	155	491
IV	71	116	145	610
V	86	80	149	562
VI	103	120	159	580
VII	133	256	139	454

[a] Two grams of sulfate of ammonia were added to each of cultures II to VII under the column *fertilized*. Under the column *unfertilized* only culture VII received 2 grams of the fertilizer.

[b] Average of two plants; one plant was excluded because its roots reached the soil below through the drainage hole.

TABLE 5

Number of flowers and young fruits and green weight of young fruits of tomatoes at the time of harvest

CULTURE NO.	NOT FERTILIZED WITH AMMONIUM SULFATE			FERTILIZED WITH AMMONIUM SULFATE		
	Number of flowers	Number of young fruits	Weight of young fruits	Number of flowers	Number of young fruits	Weight of young fruits
			grams			*grams*
I	33	0	0	18	2	X [a]
II	24	3	4.5	90	4	6.5
III	16	1	0.5	78	9	17.0
IV	20	2	1.8	67	9	40.5
V	14	0	0	80	8	33.5
VI	23	0	0	93	10	28.9
VII	74	4	8.0	54	1	2.3

[a] Less than 0.5 gram.

TABLE 6

The p^H values of the different culture media

CULTURE NO.	CULTURE MEDIA	ph	
		UNFERTILIZED	FERTILIZED [a]
I	Soil alone, 5 kgm. air dry (not fertilized) ..	6.18	6.23
II	1/2 soil + 1/2 ash by volume, or 3.5 kgm. soil + 4.3 kgm. ash	5.75	6.20
III	Soil, 5 kgm. + ash 1 cm. thick, or 417 grams	5.87	6.17
IV	Soil, 5 kgm. + ash 2 cm. thick, or 834 grams	6.40	6.73
V	Soil, 5 kgm. + ash 4 cm. thick, or 1668 grams	5.93	6.32
VI	Soil, 5 kgm. + ash 6 cm. thick, or 2502 grams	5.93	5.99
VII	Soil, 5 kgm. + 2 grams ammonium sulfate ..	6.04	6.15

[a] Cultures II to VI in the fertilized set were each treated with 2 grams of ammonium sulfate fertilizer.

TABLE 7

Computed data of Mayon ash, available P_2O_5 and K_2O contents, and equivalent superphosphate and potassium sulfate

CULTURE NO.	MAYON ASH ADDED AND CONTENTS				AMOUNT OF FERTILIZER TO PRODUCE THE SAME AMOUNT OF P_2O_5 AND K_2O	
	Thickness	Per hectare	P_2O_5	K_2O	Superphosphate	Potassium sulfate
	cm.	*kgm.*	*kgm./ha.*	*kgm./ha.*	*kgm./ha.*	*kgm./ha.*
I	none	none	none	none	none	none
II	10.2	1,224,000	514.1	159.1	2,856	332
III	1.0	120,000	50.4	15.6	280	33
IV	2.0	240,000	100.8	31.2	560	65
V	4.0	480,000	201.6	62.4	1,120	130
VI	6.0	720,000	302.4	93.6	1,680	195
VII	none	none	none	none	none	none

THE VALUE OF FIRST GENERATION HYBRID SEED OF SOME REGIONAL STRAINS OF LAGKITAN CORN[1]

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Of the Department of Agronomy

This is the second of the series of investigations on the value of the first generation of hybrid Philippine corn seed. In the first paper of Capinpin and Padilla, (1938)[2] it was reported that increased production of corn ear and shelled grains, presumably resulting from hybrid vigor, was realized in all crosses between geographical strains of Native Yellow Flint corn. Like the Native Yellow corn, Lagkitan is represented by geographical or regional strains. This variety is gaining popularity as green corn because of its superior eating quality. Its use as a rice substitute in some parts of the Philippines will likely extend the culture of this variety; consequently, experiments on the means of increasing its yield become necessary. The literature dealing with tests of productivity of first generation hybrids between more or less related forms of maize is adequately considered in the paper of Capinpin and Padilla (1938)[2].

This work was undertaken with the following objects: (*a*) to study hybrid vigor in the first-generation crosses between regional strains of Lagkitan corn, and (*b*) to determine whether or not the increased yields, if any, owing to heterosis justify the expenses of producing such crossed seed.

The experiments were conducted in the Experiment Station fields of the Department of Agronomy, from May, 1937, to September, 1938.

MATERIALS AND METHODS

Strains of Lagkitan variety of corn

Three strains of Lagkitan variety of corn were used in these experiments. They were designated as Abra, Cagayan, and Laguna. All were named after the province from which the seeds were obtained.

Description of Lagkitan variety. The Lagkitan variety of corn can be distinguished from other varieties by the characteristic white-

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[1] Experiment Station contribution No. 1315.

[2] CAPINPIN, J. M., AND E. B. PADILLA. 1938. The value of first generation hybrids of Native Yellow Flint Corn. The Philippine Agriculturist 27: 405–425. *With 4 text figures.*

ness of its kernels, which are generally opaque or pearly white in color.

Lagkitan variety was found to be, in general, a non-suckering variety.

Description of strains. The ears of the strains used appeared similar in size and shape. Little differences were noted in the periods of flowering. The Abra strain produced tassels forty-four days after planting, and silk from three to seven days after the appearance of the tassel; the Laguna strain produced tassels in approximately the same time as the Abra, and silk about three or four days after the tassel; the Cagayan strain was somewhat late, producing tassels from forty-six to fifty days after sowing and showing silk from three to seven days after the appearance of the tassels.

The seed corn used in the experiments came from the provinces of Abra, Cagayan, and Laguna.

Preparation of seeds for planting

The parental strains, designated as Abra, Cagayan, and Laguna, obtained from the first-generation culture by the plant breeding division were used as sources of materials for this study. One hundred ears from each strain were selected. Those with opaque and pearly white kernels were selected, whereas all ears with flinty grains were eliminated. The ears of these strains were hand-shelled, and the kernels were kept separately and labeled.

Hybridization plots

Preparation of the breeding plots. An isolated piece of land in the Experiment Station of the Department of Agronomy was devoted to this work. The land was plowed three times with native plows and harrowed once after each plowing. After the last harrowing, plots were laid out. Each measured ten by ninety meters, or had an area of approximately nine hundred square meters. They were laid side by side about twenty-five meters from one another. Furrows were laid out lengthwise and distanced one meter apart. Ten furrows in each plot were devoted to corn, and two extra rows at each side of the plot were planted to sorghum to act as barriers against pollen grains from other plots.

Wet-season hybridization plots. Planting began immediately after the furrows were laid out. Two strains were planted alternately in each plot, one row to be detasseled and the other to remain intact. The furrows were put in such a way as to be in a crosswise position against the direction of the wind. The rows were set so that the prevailing wind would carry the pollen from the undetasseled male plants to the detasseled ones. Planting was done on May 15, 1937; seeds were planted seventy centimeters between hills in rows set one meter apart. Planting was done by hand, four seeds to a hill.

Method of detasseling. The Abra strain produced tassels in forty-four days; silk appeared from three to seven days after the tassels showed at the leaf sheath. The Cagayan strain produced tassels in forty-six days, and silk from three to seven days afterwards. The Laguna strain commenced its flowering at approximately the same time as the Abra. Detasseling was done by pulling off the tassels as soon as they appeared and before the anthers opened. No artificial cross-pollination between strains was done. The wind was the only natural agent for carrying pollen from one plant to another. Detasseling, which lasted about twenty-seven to tweny-nine days because the plants did not bloom on the same day, was done every other day. The time spent in this work and the number of plants detasseled were recorded.

Harvesting. Harvesting from the wet-season hybridization plots was done ninety-seven days after planting. Each strain and each combination was harvested separately; the ears were husked right in the field, and the clean ears then put into sacks and properly labeled. The ears were dried in the sun for ten days, after which they were shelled by hand. The volume of shelled grains of each strain and each hybrid combination was determined.

Other observations. During the growing season, the field was cultivated twice; even then the weeds grew heavily because the corn plants did not grow tall. A severe typhoon lasting six days occurred from July 28 to August 2. Plants were then at the milk stage and were blown away. A great number of the ears were badly attacked by rats. All these factors account for the comparatively low yield of each strain and combination.

Dry-season hybridization planting. As it was feared that the amount of seed obtained from the wet-season hybridization planting would not be enough for both comparative cultures, another set of breeding plots was laid out in the dry season; each plot had an area of 500 square meters (10 × 50 meters). Planting began on January 14, 1938, and the crop was harvested on April 21, 1938, or ninety-seven days after. The procedure followed in this planting was practically the same as that in the wet-season planting. Very little rain fell at the beginning of this season. This period was later followed by a long interval of dry weather with the consequence that the plants looked sickly at tasseling time. Laborers had to be employed to water the plants in the entire field for a period of over two weeks every day.

Comparative cultures

Dry-season planting. Seeds of F_1 crossbred strains as well as their parents were planted in plots replicated five times. Each plot had an area of 400 square meters (20 m. × 20 m.). The land for this planting was located in the Experiment Station field east of the orchard area toward the creek. It had an area of 12,000 square meters, which was just enough to accommodate all replicated plots. Land preparation was delayed by bad weather. The field was plowed four times and harrowed once after each plowing. The first plowing was done with a tractor, and the rest with native plows. Planting began on November 26, 1937, immediately after the land was properly leveled. The plots were so distributed that each strain and each hybrid covered all apparent soil variations in different parts of the field. Furrows were laid one meter apart and the hills, 70 centimeters. All planting operations were done by hand, seeds being planted at the rate of four to each hill. The amount of seed used for each strain and each combination was recorded. The crop was harvested on March 2, 1938, ninety-six days after planting.

Wet-season planting. A different piece of land located at the far end of the Experiment Station near the railway was used in this planting. It has an area of 15,000 square meters, enough to accommodate thirty plots of 500 square meters each. The land was prepared by plowing and harrowing it three times with native implements. Planting began on May 20, 1938, immediately after the field had been properly prepared. The procedure in planting was the same as that for the dry-season planting.

Harvesting. Harvests from each plot were gathered separately in the dry season. After the ears had been husked in the field, they were placed in sacks properly labeled; then they were dried in the sun for about a week and weighed. After being weighed, the ears were shelled by hand as ears obtained from the dry-season culture were very small and could not be shelled by the machine. After being shelled, the grains were weighed again and the volume measured separately for each plot.

In the wet season, the matured plants were allowed to dry in the field for five or six days before the ears were gathered. It took four days to harvest the crop with an average of seven laborers for each day. The ears were stored separately on a concrete floor and taken out to dry in the sun whenever the weather permitted. After ten days drying, the ears were shelled with the shelling machine and by hand; the grains were again weighed and the volume measured.

Field study of each strain and hybrid in both dry- and wet-season plantings

Measurements of height. Measurements of heights of plants began when the flowers were fully exposed uniformly throughout the plots. One hundred plants from each combination and parent strain were picked at random from all the plots and measured from the surface of the ground up to the blade joint of the flag leaf of the plant. The same procedure was followed in all plantings.

Weight of the ear. One hundred ears from each combination and parent strain were picked at random from all plots at harvesting time. The ears were husked and dried thoroughly; then they were weighed singly, or ear by ear. After being weighed, each ear was shelled by hand and the grains weighed again in order to find the shelling percentage.

RESULTS AND DISCUSSION

Height of parent strains and F_1 hybrids

A fairly reliable index of growth vigor of crop is the average height of plants. Table 1 shows that all F_1 hybrids exceeded both of their respective parents in height. All combinations showed a significant increase in height over one of the parents.

In the dry season, plants were comparatively short; this was largely due to unfavorable conditions then existing. The coefficient of variation ranged from 26.09 to 33.31 per cent.

In the wet-season planting, however, the coefficients of variation in height were not so high as those of the dry-season, the range being 10.10 to 14.14 per cent.

Weight per 100 ears of parents and F_1 hybrids and the shelling percentage of each

It will be noted in table 2 that all the F_1 hybrids planted during the dry season showed significant increases in weight per ear over either of the parents. The results of weight of clean ears during the wet season showed that with the exception of the (Abra × Laguna) F_1 hybrid, all other hybrids exceeded significantly the weight per ear of both parents.

The shelling percentage was not markedly different in parental strains and hybrid plants, but considerably higher in the wet-season planting than in the dry.

Field uniformity of the F_1 hybrids and parents

Uniformity in growth and vigor of the plants was observed during the entire growing season of the plants. In the dry-season planting, (Abra × Laguna) F_1 and the (Laguna × Cagayan) F_1 proved to be much better than either of their parents in growth, being more vigorous and healthier. The tassels appeared earlier among the best hybrids; the earliest appearance recorded was in fifty days. Tassels appeared as late as fifty-seven days or more among the parents. The F_1 hybrid (Cagayan × Abra) did not thrive well and the growth was only fair; its condition was similar to that of its parents. The parent Laguna was the best among the parent strains, thriving best under local conditions. The maturity was not uniform throughout the field. The vigorous plants were observed to mature earlier.

In the wet-season planting, the stand of the plants was much better than in the dry season owing to a more favorable environment. Germinations were high and uniform throughout the field in both F_1 hybrids and the parents. The F_1 hybrids (Abra × Laguna) and (Cagayan × Abra) were very vigorous and uniform in growth. The F_1 hybrid (Laguna × Cagayan), although not very vigorous, showed a certain degree of uniformity and vigor. The parent Abra was very vigorous and compared favorably with its two hybrid progeny. The plants of the parent Laguna were small and slender, not vigorous, but they exhibited a certain degree of uniformity. The parent Cagayan being late in flowering, showed a certain degree of vigor but was not very uniform in growth. Flowering was observed as early as forty-two days among the F_1 hybrid (Abra × Laguna) and (Cagayan × Abra), which were closely followed by the parent Abra, the F_1 hybrid (Laguna × Cagayan) and the parent Laguna. In about forty-six days, flowers appeared throughout the field with the exception of the parent Cagayan which produced tassels as late as fifty-one days. Silk was observed generally to appear about three to eight days after the tassels.

Combinations of strains which outyielded one or both parents in the first-generation

It is apparent in tables 3 and 4, that the F_1 combinations of all strains gave higher yield of ears and shelled grains than either of the parent strains.

Table 5 shows that in the dry-season culture all of the F_1 hybrids outyielded either one of their parents. The percentage of increase in the yield of the F_1 crosses over their lower yielding parent ranged from 4.26 per cent to 76.22 per cent, and the increase in the yield of the F_1 hybrids over the average of both parents ranged from 3.32 per cent to 54.96 per cent. The percentage of increase in the yield of these hybrids which yielded more than their higher yielding parents was from 2.39 per cent to 38.27 per cent.

In the wet-season planting, it will be noted that while all of the F_1 hybrids exceeded their lower yielding parent and the average of both parents, yet only two hybrids, (Cagayan × Abra) F_1 and (Abra × Laguna) F_1, exceeded the higher yielding parents. The percentage of increase in the yield of the F_1 hybrids over their lower yielding parent ranged from 29.46 per cent 62.50 per cent, and the increase in the yields of the F_1 hybrids over the average of both parents ranged from 8.63 per cent to 26.96 per cent. The percentage of increase in the yield of those hybrids over their higher yielding parent ranged from 4.18 per cent to 17.21 per cent.

Use of F_1 hybrid vigor for increasing the yield in both dry- and wet-season crops

The foregoing data show that under the conditions of the experiment, the utilization of some of these regional strains of Lagkitan corn becomes advantageous, for two out of three combinations have shown an increased yield over both of their corresponding parents. Only one combination yielded less than its higher yielding parent, but its increased yield over the lower yielding parent exceeded the difference between its yield and that of its higher yielding parent. This result shows that crossbreeding cannot be used indiscriminately to increase yield.

Increased yields, cost of producing crossbred seed, and profits in both dry- and wet-season crops

Crossbred seeds obtained from the wet-season hybridization plots were used as planting materials for the dry-season comparative cultures. Likewise, the crossbred seeds from dry-season hybridization plots were used for the wet-season culture.

The labor cost in detasseling was determined at the rate of ₱0.10 an hour for each laborer. No expense was incurred in cross-pollination, and the cost of producing F_1 seeds was so small that increased yield of corn may be obtained with F_1 seed very reasonably.

Reference to tables 6 and 7 will show that in all plantings there was a profit from F_1 hybrids when compared with both parents or with one parent, but a loss when compared with the other parent. The F_1 hybrids, which gave a profit as compared with both parents, were (Abra × Laguna) F_1 and (Cagayan × Abra) F_1 (table 7). The combination which gave a profit over one parent but a loss when compared with the other was (Laguna × Cagayan) F_1; however, the loss sustained was more than compensated for by the profit.

SUMMARY AND CONCLUSIONS

The results obtained from these investigations may be summarized as follows:

1. A significant increase in the height of F_1 hybrid plant occurred. In this character, all combinations exceeded both of their respective parents in both plantings.

2. The F_1 hybrids also exceeded both of their parents in weight of ear in the dry-season planting. This was also true in the wet-season culture with the exception of the combination (Abra × Laguna) F_1 which was lower than its parent Abra for this character.

3. In yield of corn ears and shelled corn, all combinations were better than the average of both parents. The increase in yield of these hybrids ranged from 2.39 per cent to 76.22 per cent in the dry-season planting, and from 4.18 per cent to 62.50 per cent in the wet season.

4. The average yield per hectare of shelled corn of each of the F_1 hybrids was higher than both of their respective parents in the dry-season crop. This was also true in the wet-season planting with the exception of the combination (Laguna × Cagayan) F_1, which was unable to outyield its parent Cagayan.

5. Profit obtained from the increase in yield for both plantings was realized in all F_1 hybrids and ranged from ₱7.34 to ₱44.27 per hectare.

TABLE 1

Variation constants in height of F_1 hybrids and parent strains

Dry-season culture

F_1 AND PARENTS	MEAN	STANDARD DEVIATION	COEFFICIENT OF VARIATION	DIFFERENCE IN MEAN F_1 PARENTS
	cm.	*cm.*	*per cent*	*cm.*
(Abra × Cagayan) F_1	49.7 ± 0.96	14.2 ± 0.68	28.57 ± 1.70	
Cagayan	47.6 ± 0.86	12.8 ± 0.61	26.89 ± 1.58	+ 2.10±1.28
Abra	43.8 ± 0.98	14.59 ± .69	33.31 ± 2.03	+ 5.90±1.36
(Abra × Laguna) F_1	56.2 ± 1.05	15.6 ± 0.74	27.75 ± 1.57	
Abra	43.8 ± 0.98	14.59 ± .69	33.31 ± 2.03	+12.4 ±1.43
Laguna	53.45 ± 0.94	13.95 ± .66	26.09 ± 1.52	+ 2.75±1.40
(Laguna × Cagayan) F_1	58.8 ± 1.05	15.5 ± 0.74	26.36 ± 1.53	
Laguna	53.45 ± 0.94	13.95 ± .66	26.09 ± 1.52	+ 5.35±1.40
Cagayan	47.6 ± 0.86	12.8 ± 0.61	26.89 ± 1.58	+11.2 ±1.35

Wet-season culture

F_1 AND PARENTS	MEAN	STANDARD DEVIATION	COEFFICIENT OF VARIATION	DIFFERENCE IN MEAN F_1 PARENTS
(Cagayan × Abra) F_1	160.2 ± 1.45	21.46 ± 1.02	13.39 ± .71	
Cagayan	146.3 ± 1.26	18.63 ± .89	11.36 ± .60	+ 13.9 ± 1.9
Abra	159.1 ± 1.52	22.5 ± 1.07	14.14 ± .76	+ 1.1 ± 2.08
(Abra × Laguna) F_1	163.4 ± 1.15	17.04 ± .81	10.42 ± .53	
Abra	159.1 ± 1.52	22.5 ± 1.07	14.14 ± .76	+ 4.3 ± 1.90
Laguna	151.5 ± 1.33	19.7 ± .94	13.0 ± .69	+ 11.9 ± 1.75
(Laguna × Cagayan) F_1	156.0 ± 1.06	15.77 ± .75	10.10 ± .52	
Laguna	151.5 ± 1.33	19.7 ± .94	13.0 ± .69	+ 4.5 ± 1.69
Cagayan	146.3 ± 1.26	18.63 ± .89	11.36 ± .60	+ 9.7 ± 1.64

TABLE 2

Variation constants of weight of clean ears per 100 ears of F_1 hybrids and parent strains and shelling percentage of each

Dry-season culture

F_1 AND PARENTS	MEAN	STANDARD DEVIATION	COEFFICIENT OF VARIATION	DIFFERENCE IN MEAN F_1 PARENTS	SHELLING PERCENTAGE
	gm.	*gm.*	*per cent*	*gm.*	
(Cagayan × Abra) F_1	25.34 ± 0.66	9.81 ± 0.46	38.71 ± 2.44	—	77.63 ± 0.55
Cagayan	18.90 ± 0.54	8.00 ± 0.38	42.33 ± 2.72	+ 6.44 ± 0.85	76.35 ± 0.41
Abra	20.03 ± 0.63	9.35 ± 0.44	46.63 ± 3.08	+ 5.31 ± 0.91	77.05 ± 0.37
(Abra × Laguna) F_1	33.89 ± 0.59	8.76 ± 0.42	25.84 ± 1.51	—	78.85 ± 0.86
Abra	20.03 ± 0.63	9.35 ± 0.44	46.63 ± 3.08	+ 13.86 ± 0.86	77.05 ± 0.36
Laguna	24.72 ± 0.64	9.57 ± 0.45	38.71 ± 2.45	+ 9.17 ± 0.87	79.70 ± 0.52
(Laguna × Cagayan) F_1	28.94 ± 0.63	9.36 ± 0.44	32.34 ± 1.97	—	79.25 ± 0.32
Laguna	24.72 ± 0.64	9.57 ± 0.45	38.71 ± 2.45	+ 4.22 + 0.89	79.70 ± 0.32
Cagayan	18.90 ± 0.54	8.00 ± 0.38	42.33 ± 2.72	+ 10.04 + 0.83	76.35 ± 0.41
Wet-season culture					
(Cagayan × Abra) F_1	98.65 ± 1.92	28.43 ± 1.36	28.82 ± 1.71	—	81.95 ± 0.28
Cagayan	80.55 ± 1.86	27.53 ± 1.31	34.17 ± 2.10	+ 18.10 ± 2.66	83.15 ± 0.26
Abra	92.85 ± 1.85	27.47 ± 1.31	29.58 ± 1.78	+ 5.80 ± 2.66	82.90 ± 0.25
(Abra × Laguna) F_1	88.35 ± 1.90	28.26 ± 1.35	31.87 ± 1.93	—	82.68 ± 0.25
Abra	92.85 + 1.85	27.47 ± 1.31	29.58 ± 1.78	— 4.50 ± 2.62	82.90 ± 0.25
Laguna	73.45 ± 1.91	28.39 ± 1.35	38.51 ± 2.43	+ 14.90 ± 2.69	82.44 ± 0.25
(Laguna × Cagayan) F_1	81.45 ± 1.76	26.15 ± 1.25	32.10 ± 1.96	—	82.22 ± 0.22
Laguna	73.45 ± 1.91	28.39 ± 1.35	38.51 ± 2.43	+ 8.00 ± 2.59	82.44 ± 0.25
Cagayan	80.55 ± 1.86	27.53 ± 1.31	34.17 ± 2.10	+ 0.90 ± 2.66	83.15 ± 0.26

TABLE 3

Comparative yield per plot of F_1 hybrids and parent strains

Dry-season culture

F_1 AND PARENTS	AVERAGE YIELD PER PLOT OF EAR CORN	AVERAGE YIELD PER PLOT OF SHELLED CORN
	kgm.	*kgm.*
(Cagayan × Abra) F_1.	4.67 ± .24	3.69 ± .15
Cagayan	4.46 ± .31	3.42 ± .20
Abra	4.43 ± .22	3.39 ± .21
(Abra × Laguna) F_1..	7.59 ± .28	5.89 ± .24
Abra	4.43 ± .22	3.39 ± .21
Laguna	5.77 ± .22	4.34 ± .17
(Laguna × Cagayan) F_1	7.58 ± .26	5.87 ± .19
Laguna	5.77 ± .22	4.34 ± .17
Cagayan	4.46 ± .31	3.42 ± .20
Wet-season culture		
(Cagayan × Abra) F_1.	171.08 ± 17.06	133.52 ± 12.82
Cagayan	131.4 ± 9.51	101.64 ± 8.70
Abra	150.5 ± 13.22	114.14 ± 9.64
(Abra × Laguna) F_1..	155.1 ± 12.27	118.9 ± 9.17
Abra	150.5 ± 13.22	114.14 ± 9.64
Laguna	106.7 ± 7.22	79.84 ± 5.67
(Laguna × Cagayan) F_1	122.1 ± 4.25	93.00 ± 2.56
Laguna	106.7 ± 7.22	79.84 ± 5.67
Cagayan	131.4 ± 9.51	101.64 ± 8.70

TABLE 4

Computed yield per hectare of F_1 hybrids and parent strains

Dry-season culture

F_1 AND PARENTS	COMPUTED YIELD PER HECTARE OF EAR CORN	DIFFERENCE F_1 PARENTS	COMPUTED YIELD PER HECTARE OF SHELLED CORN		DIFFERENCE F_1 PARENTS	
	kgm.	*kgm.*	*kgm.*	*cavan*	*kgm.*	*cavan*
(Cagayan × Abra) F_1	116.90	—	89.75	1.71	—	—
Cagayan	111.60	+ 5.30	85.50	1.67	+ 4.25	+ 0.04
Abra	110.75	+ 6.15	84.75	1.64	+ 5.00	+ 0.07
(Abra × Laguna) F_1	189.75	—	147.25	2.89	—	—
Abra	110.75	+ 79.00	84.75	1.64	+ 62.50	+ 1.25
Laguna	144.25	+ 45.50	108.50	2.09	+ 38.75	+ 0.80
(Laguna × Cagayan) F_1	189.50	—	146.75	2.85	—	—
Laguna	144.25	+ 45.25	108.50	2.09	+ 38.25	+ 0.76
Cagayan	111.60	+ 77.90	85.50	1.67	+ 61.25	+ 1.18
Wet-season culture						
(Cagayan × Abra) F_1	3421.6	—	2670.4	46.04	—	—
Cagayan	2628.0	+ 793.6	2032.8	34.84	+ 637.6	+ 11.20
Abra	3010.0	+ 411.6	2282.8	39.28	+ 387.6	+ 6.76
(Abra × Laguna) F_1	3102.0	—	2378.0	40.92	—	—
Abra	3010.0	+ 92.0	2282.8	39.28	+ 95.2	+ 1.64
Laguna	2134.0	+ 968.0	1596.8	25.18	+ 781.2	+ 15.74
(Laguna × Cagayan) F_1	2440.8	—	1860.0	32.60	—	—
Laguna	2134.0	+ 306.8	1596.8	25.18	+ 263.2	+ 7.42
Cagayan	2628.0	— 187.2	2032.8	34.84	— 172.8	— 2.24

TABLE 5

Increase or decrease in the yields of F_1 hybrids over or below the yields of parent strains per hectare of shelled corn

Dry-season culture

F_1 AND PARENTS	HYBRID OVER (+), OR BELOW (—), LOWER YIELDING PARENT	HYBRID OVER (+), OR BELOW (—), HIGHER YIELDING PARENT	HYBRID OVER (+), OR BELOW (—), AVERAGE OF PARENT
	per cent	*per cent*	*per cent*
(Cagayan × Abra) F_1.			
Abra	+ 4.26	—	—
Cagayan	—	+ 2.39	—
Average of parents	—	—	+ 3.32
(Abra × Laguna) F_1			
Abra	+ 76.22	—	—
Laguna	—	+ 38.27	—
Average of parents	—	—	+ 54.96
(Laguna × Cagayan) F_1			
Cagayan	+ 70.65	—	—
Laguna	—	+ 36.36	—
Average of parents	—	—	+ 51.59
Wet-season culture			
(Cagayan × Abra) F_1.			
Cagayan	+ 32.14	—	—
Abra	—	+ 17.21	—
Average of parents	—	—	+ 24.25
(Abra × Laguna) F_1			
Laguna	+ 62.50	—	—
Abra	—	+ 4.18	—
Average of parents	—	—	+ 26.96
(Laguna × Cagayan) F_1			
Laguna	+ 29.46	—	—
Cagayan	—	— 6.43	—
Average of parents	—	—	+ 8.63

TABLE 6

Gain or loss per hectare of shelled corn from the use of F_1 hybrid seeds

Dry-season culture

F_1 AND PARENTS	COMPUTED INCREASE (+), OR DECREASE (—), IN YIELD OF F_1 HYBRIDS	VALUE INCREASE (+), OR DECREASE (—), AT ₱2.70 PER CAVAN	COMPUTED COST OF PRODUCING SEEDS PER HECTARE	PROFIT (+), OR LOSS (—), FROM THE USE OF F_1 HYBRID SEEDS
	cavan	*pesos*	*pesos*	*pesos*
(Cagayan × Abra) F_1				
Cagayan	+ 0.04	+ 0.108	0.43	— 0.322
Abra	+ 0.07	+ 0.189	0.43	— 0.241
(Abra × Laguna) F_1				
Abra	+ 1.25	+ 3.370	0.29	+ 3.08
Laguna	+ 0.80	+ 2.16	0.29	+ 1.87
(Laguna × Cagayan) F_1				
Cagayan	+ 1.18	+ 3.186	0.37	+ 2.816
Laguna	+ 0.76	+ 2.052	0.37	+ 1.682

TABLE 7

Gain or loss per hectare of shelled corn from the use of F_1 hybrid seeds

Wet-season culture

F_1 AND PARENTS	COMPUTED INCREASE (+), OR DECREASE (—) IN YIELD OF F_1 HYBRIDS	VALUE INCREASE (+), OR DECREASE (—), AT ₱2.70 PER CAVAN	COMPUTED COST OF PRODUCING SEEDS PER HECTARE	PROFIT (+), OR LOSE (-), FROM THE USE OF F_1 HYBRID SEEDS	TOTAL PROFITS (+), OR LOSSES (—) FOR BOTH SEASON CULTURES
	cavan	*pesos*	*pesos*	*pesos*	*pesos*
(Cagayan × Abra) F_1					
Cagayan	+ 11.20	+ 30.24	+ 0.128	+ 30.112	+ 29.790
Abra	+ 6.76	+ 18.252	+ 0.128	+ 18.124	+ 17.883
(Abra × Laguna) F_1					
Abra	+ 1.64	+ 4.428	+ 0.096	+ 4.332	+ 7.340
Laguna	+ 15.74	+ 42.498	+ 0.096	+ 42.402	+ 44.272
(Laguna × Cagayan) F_1					
Laguna	+ 7.42	+ 20.033	+ 0.10	+ 19.933	+ 22.749
Cagayan	— 2.24	— 6.048	+ 0.10	— 6.148	— 4.466

FURTHER STUDIES ON THE BREEDING HABITS OF THE CARABAO[1]

ANTONIO R. OCAMPO

WITH TWO TEXT FIGURES

Very little attention has been given to the breeding habits of the carabao as little control has been exercised over its breeding in this country. After the day's work, the carabaos are usually let loose on common grazing grounds or tethered in grassy fields, where the carabao cows that are in oestrus are usually bred by wandering bulls. Further work on the subject is necessary because the data on the breeding habits of the carabao as compared with other kinds of livestock are meager.

Review of literature

The earliest work on the subject available to the writer was that of Gonzalez (1919). Working with animals of the College of Agriculture, he reported that the period of gestation among carabaos was from 318 to 324 days and that oestrus occurred on an average of 54 days after calving.

According to Levine (1920), the gestation period of the water buffalo varied from ten to eleven months. The same author, in another publication (1923), states that in South China, among water buffaloes, the gestation period with bull calves was 347 days and 338 days with heifer calves.

Hansen, cited by Gonzalez and Esguerra (1927), states that mating between water buffaloes and domestic cattle was not unusual, although there had not been an authenticated case of impregnation, and that hybrids were, therefore, unknown. The experiments carried out by Gonzalez and Esguerra in which a bull was likewise used with carabao cows failed to produce hybrids.

Ulvi (1927) mentions that one of the difficulties with the water buffalo as a milch animal was the long dry period between lactations among many of the animals. Certain strains, however, differed very much in this respect and were known to be highly fertile. According to him, certain concentrates notably "matar" peas (*Lathyrus sativus* Linn.), cotton seed, bran, and oil-cake were considered useful to arouse sex desire in the bull. In lower Sind, ripe "babul" pods (*Acacia arabica* Willd.) were recommended as the best feed to bring buffaloes quickly into heat, whereas some breeders administered heavy doses of oil or butter for the same purpose. Although certain animals were generally ready to receive the bull a few months after the birth of a calf, according to the same author, most were very irregular and one calf in two years was about the general standard. Normally a buffalo cow would bear six calves during its lifetime, while under favorable conditions, ten calves might be produced.

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[1] Experiment Station contribution No. 1316. Prepared in the Department of Animal Husbandry under the direction of Associate Professor Valente Villegas.

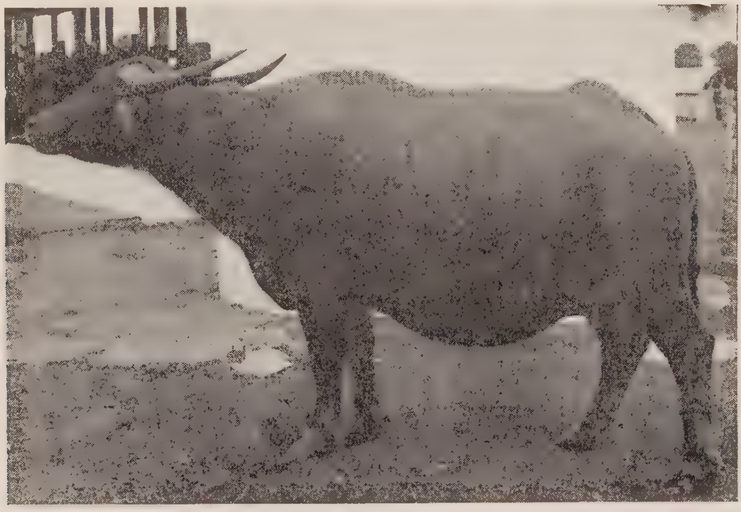

Fig. 1. Philippine carabao cow No. 39 six days before parturition. Note pendant belly, sway back, sloping rump, and hollow above tail head.

According to Villegas (1928), the preponderance of sexual activity among carabaos seemed to occur between August and January, during the cooler, wet months of the year.

Villegas (1930) gives the average approximate age at first fertile mating among Philippine carabaos, Indian buffaloes, and Indian buffalo-Philippine carabao crossbreeds in the College of Agriculture as 2 years, 4 months, and 7 days. The average interval between calvings was 535.6 days; the majority of cases ranged from 12 to 18 months. The average rest period or the time elapsing between one calving and the following conception was 215 days, ranging from 1 to 7 months.

Kothavala (1935), in regard to the breeding qualities of the Indian buffalo, states that compared to the breeds of Zebu cattle, it is a late maturing animal. On an average, it bears the first calf at the age of four years; its period of gestation is ten and one-half months.

According to Kanagaratnam (1935), there was little control over the breeding of Indian buffaloes in the Kuala Lumpur district and environs. The general practice was to select a promising bull for service in a herd of from twenty to thirty cows. The bulls were fit for service between two and a half and three years of age.

He further states that the stud efficiency of a well-cared bull continued until the eighth year, after which it declined, and the animal was then sold for slaughter. The heifers were allowed to breed when three years of age; the period of gestation was about ten and a half months. The period of oestrus took place about every thirty days and might occur one or two months after calving.

According to Littlewood (1936), the gestation period of the Indian buffalo is 310 days.

Objects of the work

The objects of the present investigation were to determine the following: (*a*) signs, duration, and recurrence of oestrus, (*b*) behavior of the carabao cow and bull at breeding time, (*c*) age at first calving, (*d*) interval between parturition and first oestrus, (*e*) signs of pregnancy and approaching parturition, (*f*) gestation period, (*g*) behavior of the carabao cow during and immediately after parturition, (*h*) reproductive season during the year, and (*i*) interval between calvings and rest period.

Time and place of the experiment

The work was conducted in the Department of Animal Husbandry, College of Agriculture, from July 29, 1936, to February 15, 1938, a period of eighteen and one-half months.

MATERIALS AND METHODS

Animals

Two Indian buffalo breeding bulls, one vasectomized Philippine bull, and eighteen carabao cows, belonging to the College of Agriculture, were used in this experiment. Of the carabao cows, seven were Philippine, three were Indian, and eight were grades. The carabao cows ranged in age from 1 year, 8 months, and 20 days, to 21 years and 14 days at the beginning of the investigation. Indian bull No. 21 was 8 years, 10 months, and 18 days; the other, No. 31, was 4 years, 5 months, and 13 days, whereas the vasectomized bull was 5 years, 9 months, and 5 days. (Table 1.)

Management of the carabao cows

Most of the carabao cows used in this investigation were a part of the College dairy herd.

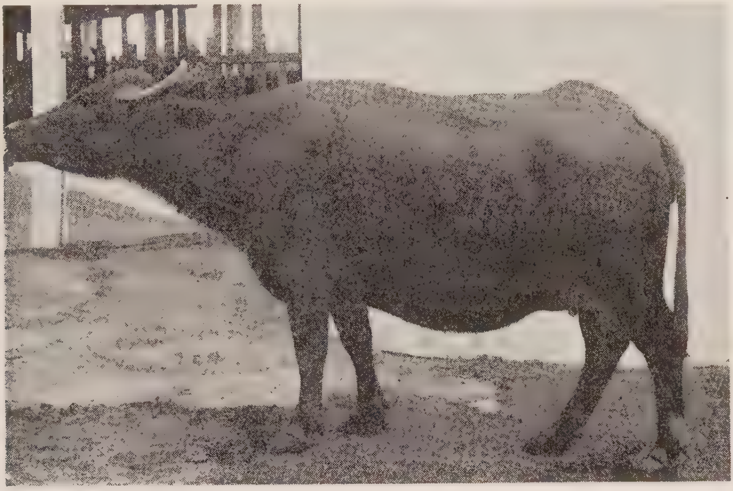

Fig. 2. Indian buffalo-Philippine carabao crossbreed No. 102 two days before parturition, showing low back, hanging abdomen, steep rump, and marked hollow at side of rump over tail head. Udder is also fairly enlarged.

Four pastures were provided for rotation purposes. A number of trees furnished shade for the animals during the hottest part of the day.

In a separate pasture of the Department of Animal Husbandry, the carabao heifers were kept with the Indian bull No. 31. In this way, carabao heifers which had come in heat for the first time were duly bred

Management of the carabao bulls

A vasectomized Philippine carabao bull was used as a teaser to determine the occurrence and recurrence of oestri. He proved to be an effective teaser yet incapable of reproduction. Examinations of his semen toward the latter part of the investigation did not show any sperms.

Indian bull No. 21 was staked in an adjacent field. He was used in breeding carabao cows from which data on gestation were obtained. Examination of his ejaculation under the microscope showed numerous active sperms.

Indian bull No. 31, in the herd of carabao heifers, maintained its condition well throughout the investigation. The fact that calves were produced by the carabao heifers with which he was associated was proof of his fertility.

Procedure in determining breeding habits

For three months, observations on the breeding habits of the animals were made from 6:00 to 7:00 a.m. and from 4:00 to 6:00 p.m. daily. As the animals were found to be more sexually active in the afternoons, in subsequent observations the work was conducted only then.

To ascertain that a carabao cow was in heat, the vasectomized bull was mixed with the herd every afternoon. The bull went over each female, and if any was found to be in heat, record of the occurrence of oestrus was made. If the animal was to be fertilized, Indian bull No. 21 was brought and permitted to mate with this animal. All carabao cows which were bred by this bull were not bred again until after the third oestrus, or about sixty days after the preceding one, in order that accurate data on the period of gestation could be secured.

Observations on the behavior of the carabao bulls as well as the carabao cows were made before and during matings. The vasectomized bull was allowed to mount the carabao cows, even if only records on oestri were to be obtained, so as to make conditions as natural as possible. Also, the behavior of the carabaos during and immediately after parturition was observed and noted.

DISCUSSION OF RESULTS

Indications, duration, and recurrence of oestrus

Oestrus was generally more marked and more readily detected in the Philippine carabaos and the grades than in the Indian buffaloes. The carabao cow that was in heat was found to meet the vasectomized bull when the latter was brought near. Sometimes the animal in oestrus roamed around the corral, at other times, stood quietly with her head held high in the air. Lack of appetite was also apparent. Many times the animal mounted other females, a behavior which was more pronounced in the Philippine carabaos than in the grades. In no case were the Indian buffaloes observed to mount other cows when they were in heat. The only means by which it was possible to determine oestrus in the Indian buffaloes was by putting the bull with the females, in which case those in heat quietly allowed the male to breed them. The presence of thick vaginal discharges was rare. This might be due to the fact that frequent urination, which is common in carabao cows in heat, had probably washed away any secretion before it could be observed. No marked change appeared in the appearance of the vulva or the udder, contrary to previous findings by Manresa and Diapo (1938) among domestic cattle. Likewise, examinations made of the lining of the vulva showed no marked difference in color.

It may be seen from table 2 that from a total of sixty oestri observed among Philippine carabaos, the majority of cases lasted one day or less. Two cases occurred, however, when oestrus lasted for four and five days, respectively. This was exhibited by animal No. 122, which was observed to be in heat January 25, 1937, and continued to show signs of heat until January 30, 1937, a period of five days. She was bred once on the first day of heat, but continued to accept the vasectomized bull every day until January 30, 1937. Again, the same carabao cow was observed to be in heat on February 18, 1937, and continued to show the same signs until February 22, 1937, a period of four days. These two cases made the average duration of oestrus for this animal, two days. Out of a total of thirty-three oestri in the Indian buffaloes, the average duration was found to be less than one day. Observations made of three Indian buffalo cows showed no case where oestrus lasted more than one day. The average duration among the grades was also less than one day, based on a total of fifty-four oestri observed. If the animals of different breeding were taken as a whole, it was found that oestrus lasted from less than one to five days, with the great majority of cases lasting less than one day.

The recurrence of oestrus among the different animals studied is summarized in table 2. Among the Philippine carabaos, the interval between oestri ranged from 27.6 to 46 days. It will be of interest to note that animal No. 9, the oldest among the cows used in the experiment, had a tendency to come in heat at longer intervals than any of the other cows. The interval between oestri among the Philippine carabaos was computed from a total of sixty cases; the average was 33.6 days. With the Indian buffaloes, this was found to be 37.1 days and the range was from 34 to 39.3 days. The interval between fifty-four oestri among the grades ranged from 20.2 to 39 days; the average was 31.3 days. The average for all the different animals studied was 33.3 days.

Wallace, cited by Marshall (1922), stated that in temperate countries, oestrus in cattle recurs oftener in summer than in winter. This investigation, however, showed that the recurrence of oestrus among water buffaloes was more or less regular throughout the year.

Behavior of the carabao cow and carabao bull at breeding time

A carabao cow that was not in heat was found to run away from the bull as if annoyed by its presence, but those which were in heat continually followed the bull and placed their heads under its neck or belly. The Philippine carabaos were observed to have a peculiar habit of playfully goring the bull. If the bull was slow to respond, the female continued to go around the bull rubbing her body against him, after which she generally placed herself in front of him.

When the carabao bulls were brought to the females, they smelled and licked the external genitalia of the females whether they were in heat or not. Then they raised their heads in the air, opened their mouths, sniffed, and usually remained in that position for a few seconds. After this, they instantly mounted the cows and mating occurred if the cows were in heat. It seems that cows in oestrus emit a peculiar odor which is readily detected by the bulls, for often they abandon certain females they have approached from behind for others.

In the case of the Indian buffaloes and in some of the grades, a peculiar grunt was made by the cows at the approach of the bull. The cow continued to grunt during mating and even afterwards. This characteristic was not observed among Philippine carabaos.

Age at first calving

The ages at first calving of eleven carabaos are presented in table 3. It may be seen from this table that among the Philippine carabaos, the youngest animal calved at 3 years, 2 months, and 20 days, and the oldest at 4 years, 3 months, and 14 days; the average

age at first calving was 3 years, 7 months, and 19 days. This is slightly higher than that reported by Villegas (1930) which was 3 years, 3 months, and 20 days.

Only one female Indian buffalo is included in this data. This was animal No. 18, which calved first at 4 years, 9 months, and 6 days. Villegas (1930) reported that the average age at first calving of Indian buffaloes was 3 years and 29 days; the range was from 2 years, 10 months, and 1 day to 3 years, 5 months, and 21 days. With the grades, the average age at first calving was 3 years, 2 months and 9 days; the range was from 2 years, 9 months, and 12 days to 3 years, 7 months, and 17 days. He further reported that the average age at first calving for animals of different breeding was 3 years 2 months, and 22 days.

Kothavala (1935) reported that, on the average, the Indian buffalo bears the first calf at four years, a year later than the Indian buffaloes of the College of Agriculture, according to Villegas (1930). In the present investigation, nothing can be said on this point as the data are only from one Indian buffalo heifer.

Interval between parturition and the next oestral period

Table 4 shows the interval between parturition and the first appearance of oestrus among the animals of different breeding. With the Philippine carabaos, the average interval was found to be 35 days; the range was from 24 to 50 days. Gonzalez (1919) found this interval to be 54 days. The shortest interval reported in this paper is that of animal No. 83, which received the bull two days after calving. This animal, however, did not give any milk and did not allow the calf to suckle; hence the interval reported was considered abnormal and was not included in obtaining the average.

With the Indian buffaloes, the average interval was found to be 49.6 days, with a range of from 45 to 53 days. With the grades, this average was found to be 44 days; the range was from 35 to 51 days. The average for all animals of various breeding was 45.8 days.

According to Ulvi (1927), Indian buffaloes vary greatly in this respect. While certain animals are generally ready to receive the bull a few months after calving, most are very irregular.

On the whole the results obtained are in agreement with the observations of Kanagaratnam (1935), who stated that the period of oestrus takes place either one or two months after calving.

Signs of pregnancy and approaching parturition

Pregnancy among the carabaos could not be ascertained until about the sixth or the seventh month. It is a common belief among animal breeders that pregnant animals cease to come in heat; hence this may be taken as a criterion in determining pregnancy. This was not true in all cases. While animals Nos. 38 and 102 never came in heat again after they were bred in December, 1936, animal 39, a Philippine carabao cow, came in heat twice after she had been bred. All three animals proved to be pregnant and to have freshened later. Again, animal No. 122 which was bred for the last time on June 19, 1937, came in heat 21 days after. This animal was also found to be pregnant.

Table 5 shows the increase in weights and measurements of the abdomen of three pregnant animals. It may be seen from this table that there was a slight improvement in the general condition of the cows as evidenced by their slight increase in weight during the first four weeks after breeding. A slight increase in the circumference of the belly was also noted. During the next two months, however, there was a decline in the weights of all the pregnant cows. With cows Nos. 38 and 102, this decrease continued until the sixth month. This may be attributed to the fact that those periods were summer months, and the condition of the pastures was rather poor. From the sixth month up to the time of parturition, however, a rapid and constant increase in the weights of the cows occurred.

The increase in the circumference of the abdomen was more or less constant from the time of breeding up to that of calving. No direct relationship seemed to exist between the increase in weight of the animal and circumference of the abdomen as shown by the fact that, although the animals decreased in weight, the circumference of the abdomen continued to increase.

A slight sagging of the back was noticed in animal No. 39 during the tenth month, whereas in the two other animals, the top line remained about the same.

Marked swelling of the external genitals was observed three weeks before calving, increasing in size until the time of parturition. Mucoid discharges from the external genitals were noted six days before calving in the case of cow No. 39. The other two animals showed such discharges two days before calving.

In all cases, a marked depression of the rump about one week before calving was noticed. This was accompanied by the appearance of a deepening or depression on either side of the sacrum, extending to the base of the tail. The anus was markedly drawn in.

Constant observations made of the udder showed that this organ enlarged considerably one week before parturition, but in no case was it found to be fully distended. At the approach of parturition, the cows became gentle. This was in contrast to what had been observed three to four months after breeding, at which stage the pregnant animals became vicious.

Gestation period

The gestation periods of five carabao cows are presented in table 6. Animal No. 39, a Philippine carabao cow, had the longest, and animal No. 10, an Indian buffalo and animal No. 102 a crossbreed, the shortest, the average for all being 316.2 days. Gonzalez (1919) found the average length of gestation among Philippine carabaos to be 324 days. Littlewood (1936) reported the gestation period of Indian buffaloes to be 310 days.

Hadley (1939) states that the duration of pregnancy varies widely with different species but within narrow limits with animals of the same species and with the same individual during different gestations.

Behavior of the carabao cow, during and immediately after parturition

Observations on the behavior of Philippine carabao cow No. 39 during and immediately after parturition was made. In this animal, labor pains started at 11:00 a.m. A portion of the foetal membrane was visible at the vulva at this time. Viscid discharges were ejected through the genital passage; then the animal lay down and got up at frequent intervals until 12:30 p.m., when the head of the foetus was seen emerging, still covered by the foetal membrane. The mother rose once again after this, and turning around, lay down on her right side with the legs alternately extended and bent at frequent intervals, accompanied by hard breathing. No moaning was heard. At 1:00 p.m. the allantoic membrane burst, discharging a copious amount of liquid, after which the foetus was forced out as far as its shoulder, aided by the contracting and relaxing muscles of the abdomen. It was evident then that the most strenuous stage of delivery from which the mother suffered was in the passage through the vagina of the head and neck of the foetus up to its front legs.

Soon after delivery, the dam, as a result of the prolonged strain she had just gone through, remained lying down with her head on the ground for about five minutes, in complete relaxation. Then she stood up and started to lick her calf. The calf first tried to rise 20 minutes later, but did not succeed until 40 minutes. Immediately, the instinct to look for the udder of the mother was manifested by the calf. Although before calving the udder did not show any secretion, at this time it became fully distended and full of milk. Also, immediately after calving, the depression of the hunger hollow appeared to be very marked. The depressions on each side of the rump above the tail head disappeared two days after calving. It is of interest to mention that during the first few days after delivery, the dams invariably moved away shielding their calves and usually had their mouths open when the bull was brought close to them.

Reproductive season during the year

Table 6 shows the different months of the year in which calves were born. It may be noted that while calves may come at any time of the year, during certain months calvings were more frequent. An examination of table 7 shows that calvings seemed to occur more frequently in the months of September, October, November, December, and January. From a total of 88 calvings, there were 13.8 per cent in September, 14.9 per cent in October, 10.3 per cent in November, 17.3 per cent in December, and 18.4 per cent in January. The combined percentages of calvings for the months of December and January was 35.7 per cent. The above findings agree fairly closely with those of Villegas (1928), who found that the preponderance of calvings took place from July to December.

Interval between calvings, and the rest period

Table 8 shows the interval between calvings, and the rest periods of carabaos. With Philippine carabaos, the average interval between calvings was found to be 415.4 days, and the average rest period, 108 days. The Indian buffaloes had an average interval between calvings of 520.6 days and an average rest period of 200.3 days. Among the grades, the average interval was 501.8 days, and the average rest period, 160.8 days. The average interval between calvings for all animals of different breeding was 479.2 days, and the average rest period, 156.9 days. It will be noted that the Indian buffalo had the tendency to drop calves at longer intervals than the Philippine carabaos or the grades. In this connection, Ulvi (1927) stated that among the Indian buffaloes one calf in two years is about the general standard. It seems likely that a much shorter rest period occurs in the Philippines. Villegas (1930) reported the average interval between calvings of carabaos of different breeding as 535.6 days, and the average rest period, 215.6 days.

SUMMARY AND CONCLUSIONS

Studies of the breeding habits of twenty-one water buffaloes, composed of eight Philippine carabaos, five Indian buffaloes, and eight grades were made. From the results of the investigation, the following summary is made:

1. The most conspicuous signs of oestrus were the following: (*a*) general restlessness, (*b*) frequent urination in small amounts, (*c*) lack of appetite, (*d*) mounting other females, (*e*) approaching the bull and rubbing her body against his, and (*f*) finally placing herself in a position to be covered. The Indian buffaloes were found to be quieter than the Philippine carabaos or the grades. No case of any Indian buffalo cow which mounted another of the same sex was observed.

2. The average duration of oestrus for all the different animals studied was less than one day.

3. The average time intervening between oestri in all carabaos studied was 33 days. The interval was longer in the Indian buffalo than in the Philippine carabaos and grades.

4. The Philippine carabao cow that was in heat playfully gored the bull. She also raised her tail at his approach. The Indian buffalo cow in heat grunted, a characteristic peculiar to this breed and apparently not shared by the Philippine carabao cows. Carabao cows that were not in heat moved away from the bull and held their tail close to the genitalia as the bull pursued them.

5. The average age at first calving of all carabao heifers was 3 years, 9 months, and 25 days.

6. Oestrus occurred on an average of 45.8 days after calving among all carabaos of different breeding.

7. Important signs of pregnancy were found to be: (*a*) general improvement in the condition of the animal, the increase in weight being more marked from the sixth month up to parturition, and (*b*) gradual increase in the size of the abdomen from the time of mating up to the date of calving.

As parturition approached, the following indications were noted: (*a*) the animal became gentle, (*b*) the external genitals enlarged, and (*c*) just a few days before delivery, hollows were formed on each side of the rump above the tail head. At the same time, the rump sloped and the belly was very pendant.

8. The average gestation period found in this investigation was 316.2 days.

9. At the inception of labor pains, the head of the foetus was already observed at the pelvic outlet. The most difficult stage the dam suffered apparently was in the passage of the foetus from the head to the shoulders, after which, delivery was relatively easy. Immediately after delivery, the mother licked its young. The calf soon attempted to rise and look for the dam's udder. The placenta was dropped two and one-half hours after calving.

10. High percentages of calvings occurred from September to January. Over one-third of all the cases during the year took place in the months of December and January.

11. The average interval between calvings among all carabaos of different breeding was 479.2 days, and the average rest period was 156.9 days. The Indian buffaloes showed longer intervals than the Philippine carabaos and grades.

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TABLE 1

Animals used in the experiment

ANIMAL NO.	AGE AT BEGINNING OF INVESTIGATION (JULY 29, 1936)	NO. CALVES PRODUCED TO END OF INVESTIGATION (FEB. 15, 1938)
	Philippine carabaos	
9	21 yrs., 14 da.	15
39	11 yrs., 2 mo., 20 da.	8
64	7 yrs., 11 mo., 1 da.	5
83	5 yrs., 10 mo., 5 da.	2
86	5 yrs., 9 mo., 5 da.	(Vasectomized bull)
89	5 yrs., 7 mo., 21 da.	
120	1 yr., 9 mo., 28 da.	1
122 [a]	Medium age	
	Indian buffaloes	
10	13 yrs., 8 mo., 7 da.	9
11	13 yrs., 7 mo., 12 da.	9
15	11 yrs., 4 mo., 11 da.	6
21	8 yrs., 10 mo., 18 da.	(Breeding bull)
31	4 yrs., 5 mo., 13 da.	(Breeding bull)
	Grade carabaos	
38	11 yrs., 11 mo., 18 da.	8
44	10 yrs., 6 mo., 23 da.	7
59	8 yrs., 9 mo., 15 da.	6
88	5 yrs., 8 mo., 19 da.	3
102	4 yrs., 12 da.	3
112	2 yrs., 10 mo., 28 da.	1
115	2 yrs., 8 mo., 4 da.	1
121	1 yr., 8 mo., 20 da.	1

[a] Purchased from outside; date of birth unknown.

TABLE 2

Recurrence and duration of oestrus

ANIMAL NO.	PERIOD OF OBSERVATION	NO. OESTRI OBSERVED	AVERAGE DURATION OF OESTRI	AVERAGE INTERVAL BETWEEN OESTRI
	Philippine carabaos		*days*	*days*
39	15—IX—'36 to 31—I—'38	6	1	34.4
83	13—VIII—'36 to 20—XI—'37	16	1—	27.6
89	24—IX—'36 to 20—XI—'37	14	1—	29.8
9	7—XII—'36 to 31—I—'38	7	1	46.0
122	1—I—'37 to 31—I—'38	6	2	31.6
64	9—I—'37 to 31—I—'38	11	1—	32.6
	Total	60	Av. 1	Av. 33.6
	Indian buffaloes			
10	26—IX—'36 to 31—I—'38	11	1—	39.3
11	3—X—'36 to 31—I—'38	12	1—	38.1
15	12—I—'37 to 31—I—'38	10	1—	34.0
	Total	33	Av. 1—	Av. 37.1
	Grade carabaos			
112	14—XI—'36 to 31—I—'38	15	1	20.2
38	23—X—'36 to 31—I—'38	3	1—	22.0
102	7—XI—'36 to 31—I—'38	3	1—	39.0
88	4—XII—'36 to 31—I—'38	11	1—	35.3
59	16—XII—'36 to 31—I—'38	9	1—	35.6
44	18—XII—'36 to 31—I—'38	10	1—	33.6
115	27—VIII—'37 to 31—I—'38	3	1—	33.5
	Total	54	Av. 1—	Av. 31.3

TABLE 3

Age at first calving

ANIMAL NO.	DATE OF FIRST CALVING	AGE AT FIRST CALVING
	Philippine carabaos	
54	10—XI—'30	3 yrs., 4 mo., 18 da.
72	30—IX—'33	4 yrs., 3 mo., 14 da.
119	21—I—'38	3 yrs., 2 mo., 20 da.
	Average	3 yrs., 7 mo., 19 da.
	Indian buffalo	
18	25—IX—'30	4 yrs., 9 mo., 6 da.
	Grade carabaos	
44	5—III—'29	3 yrs., 1 mo., 29 da.
59	6—X—'30	2 yrs., 11 mo., 22 da.
88	5—III—'33	2 yrs., 3 mo., 25 da.
102	6—IX—'35	3 yrs., 1 mo., 19 da.
112	8—VIII—'36	2 yrs., 11 mo., 7 da.
121	6—I—'38	3 yrs., 1 mo., 27 da.
115	27—VIII—'37	3 yrs., 9 mo., 2 da.
	Average	3 yrs., 21 da.

TABLE 4

Interval between calving and first oestrus

ANIMAL NO.	DATE OF CALVING	OCCURRENCE OF FIRST OESTRUS	LAPSE OF TIME AFTER CALVING
	Philippine carabaos		*days*
39	15—IX—'36	26—X—'36	41
39	26—X—'37	15—XII—'37	50
64	9—I—'37	3—II—'37	25
83	30—VIII—'36	1—IX—'36	(2)[a]
122	1—I—'37	25—I—'37	24
	Average		35
	Indian buffaloes		
10	26—IX—'36	18—XI—'36	53
11	3—X—'36	23—XI—'36	51
15	12—I—'37	26—II—'37	45
	Average		49.6
	Grade carabaos		
38	23—X—'36	11—XII—'36	49
38	22—X—'37	7—XII—'37	46
44	18—XII—'36	7—II—'37	51
59	16—XII—'36	27—I—'37	42
88	4—XII—'36	12—I—'37	39
102	7—XI—'36	12—XII—'36	35
102	22—X—'37	5—XII—'37	44
115	27—VIII—'37	12—X—'37	46
	Average		44

[a] Not included in average. She had no milk after calving and refused to nurse her calf.

TABLE 5

Weights and measurements of the body at abdomen of pregnant carabaos at four-week periods

FOUR-WEEK PERIODS	ANIMAL NO. 39 (BRED DEC. 10, 1936)				ANIMAL NO. 38 (BRED DEC. 11, 1936)				ANIMAL NO. 102 (BRED DEC. 12, 1936)			
	Weight		Circumference of body at abdomen		Weight		Circumference of body at abdomen		Weight		Circumference of body at abdomen	
	Actual	Percentage increase or decrease	Actual	Percentage increase or decrease	Actual	Percentage increase or decrease	Actual	Percentage increase or decrease	Actual	Percentage increase or decrease	Actual	Percentage increase or decrease
	kgm.		*cm.*		*kgm.*		*cm.*		*kgm.*		*cm.*	
First	543.6	2.07	250.0		544.1	1.30	248.0		484.2	0.70	238.0	
Second	546.3	0.41	250.2	0.08	539.5	—0.83	249.2	0.50	476.2	— 1.66	237.2	—0.31
Third	537.7	— 0.48	252.7	9.92	534.0	—1.02	252.0	1.10	475.7	— 0.11	237.8	0.21
Fourth	525.7	— 2.28	255.2	1.01	525.2	—1.67	252.8	0.29	471.0	— 0.98	238.2	0.42
Fifth	548.6	7.40	259.2	1.57	524.3	—0.17	253.8	0.39	471.7	0.14	239.8	0.62
Sixth	548.6	0.00	265.8	2.50	516.2	—1.58	254.2	0.19	466.5	— 1.11	240.2	0.20
Seventh	591.4	7.79	271.8	2.25	559.3	8.34	259.2	1.96	502.4	7.70	244.2	1.66
Eighth	614.2	3.90	274.8	1.10	563.4	0.74	260.0	0.28	530.9	5.66	248.8	1.84
Ninth	620.2	1.00	276.5	0.63	582.7	3.42	255.8	2.21	539.0	1.51	251.2	1.00
Tenth	638.8	3.00	379.5	1.08	593.5	1.84	268.5	1.03	551.9	2.39	253.8	0.99
Eleventh	653.7	2.32	281.5	0.71	612.0	3.11	270.0	0.55	267.0	2.75	254.0	0.09
After calving	519.8	—24.03	263.0	—6.73	594.2	—7.74	260.0	—3.84	489.0	—15.96	244.0	—4.50

TABLE 6

Gestation period

ANIMAL NO.	BREEDING	DATE BRED	DATE OF CALVING	GESTATION
				days
10	Indian	27—VI—'37	7—V—'38	314
39	Philippine	10—XII—'36	26—X—'37	320
122	Philippine	19—VI—'37	3—V—'38	318
38	½ Indian–½ Philippine	11—XII—'36	22—X—'37	315
102	½ Indian–½ Philippine	12—XII—'36	22—X—'37	314
			Average	316.2

TABLE 7

Months in which calves were born

ANIMAL NO.	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.
Philippine carabaos												
9	1	1	3	2	—	1	1	1	1	1	1	2
39	2	—	—	—	1	—	1	—	2	1	—	1
64	1	—	—	—	—	—	—	—	—	1	—	3
83	—	—	—	—	—	1	—	1	—	—	—	—
122	1	—	—	—	—	—	—	—	—	—	—	1
120	1	—	—	—	—	—	—	—	—	—	—	—
Indian buffaloes												
10	4	—	—	—	—	—	—	—	3	—	1	1
11	1	1	—	—	—	—	—	—	3	3	—	1
15	3	—	—	—	—	—	—	—	—	—	2	1
Grade carabaos												
38	—	1	—	—	—	—	—	—	1	4	2	—
44	1	1	1	—	—	—	—	1	—	—	2	1
59	—	—	1	—	—	—	—	—	—	2	1	2
88	—	—	1	—	—	—	—	—	—	—	—	2
102	—	—	—	—	—	—	—	—	2	1	—	—
112	—	—	—	—	—	—	—	1	—	—	—	—
115	—	—	—	—	—	—	—	1	—	—	—	—
121	1	—	—	—	—	—	—	—	—	—	—	—
Total	16	4	6	2	1	2	2	5	12	13	9	15
Percentage	18.4	4.6	6.9	2.3	1.2	2.3	2.3	5.7	13.8	14.9	10.3	17.3

TABLE 8

Interval in days between calvings and rest period among carabaos

ANIMAL NO.	1ST AND 2ND	2ND AND 3RD	3RD AND 4TH	4TH AND 5TH	5TH AND 6TH	6TH AND 7TH	7TH AND 8TH	8TH AND 9TH
Philippine carabaos								
9	510	428	541	390	432	355	350	337
39	290	565	413	348	611	720	406	—
64	406	384	369	373	—	—	—	—
83	434	—	—	—	—	—	—	—
122	367	—	—	—	—	—	—	—
Indian buffaloes								
10	642	799	408	375	335	382	588	380
11	664	1,062	505	343	(Aborted)	327	344	397
15	742	533	890	330	416	—	—	—
Grade carabaos								
38	743	495	613	398	718	335	359	—
44	511	458	380	433	437	719	—	—
59	365	454	609	413	384	—	—	—
88	1,004	335	—	—	—	—	—	—
102	366	410	—	—	—	—	—	—

TABLE 8 (continued)

ANIMAL NO.	9TH AND 10TH	10TH AND 11TH	11TH AND 12TH	12TH AND 13TH	13TH AND 14TH	14TH AND 15TH	AVERAGE INTERVAL BETWEEN CALVINGS	AVERAGE REST PERIODS
Philippine carabaos								
9	415	446	409	395	347	(Aborted)	414	94
39	—	—	—	—	—	—	479	159
64	—	—	—	—	—	—	383	63
83	—	—	—	—	—	—	434	177
122	—	—	—	—	—	—	367	47
Indian buffaloes								
10	—	—	—	—	—	—	488	168
11	—	—	—	—	—	—	491	171
15	—	—	—	—	—	—	582	262
Grade carabaos								
38	—	—	—	—	—	—	523	203
44	—	—	—	—	—	—	474	154
59	—	—	—	—	—	—	445	120
88	—	—	—	—	—	—	679	359
102	—	—	—	—	—	—	388	68

A COMPARATIVE STUDY OF TWO BUD SPORTS OF CASSAVA AND THEIR PARENT VARIETIES[1]

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Cassava (*Manihot utilissima* Pohl) has long been propagated commercially by cuttings. In the course of its propagation, bud sports undoubtedly have been and are being produced. When planted with the mother variety a sport so produced may affect the latter's yield. How much this effect is has not yet been determined. Hence this study of the yield and other agronomic characteristics of cassava varieties which are known to have originated as bud sports was undertaken.

As far as the writer is aware, bud sport in cassava was first mentioned by Dr. N. B. Mendiola in a lecture given by him before the University of the Philippines Biology Club in the Agronomy Lecture Hall on September 14, 1930. His description of the bud sport is quoted as follows:

> ....the color of the cassava leaf is ordinarily solid green. However, in Java, I saw a plant which was producing branches bearing leaves such as you see in this plant. You notice that the color of the leaves of this plant at the center of the lobes is yellow when the leaf is young and white when it is old. Such branches are mutations because when they are planted by cuttings, the yellow and white colors are again reproduced in the new plants. The plants I have here, which, because of the yellow and white color at the center of the lobes of the leaf, is quite ornamental in appearance, was grown originally from a cutting of this particular mutation in Java. That this mutation is only somatic and not germinal has been proved by the fact that of the many plants we have raised from seed of the mutant, not a single one has reproduced the yellow or white color at the leaf.

Another bud sport in cassava was reported in a paper read for Dr. N. B. Mendiola by Dr. J. M. Capinpin before the first Philippine Science Convention (Mendiola, 1932).

The objects of the work were: (*a*) to compare the yield and other important agronomic characteristics of two cassava bud sports and their parent varieties, and (*b*) to determine the frequency of occurrence of such bud sports in a culture.

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[1] Experiment Station contribution No. 1317. Read before the Los Baños Biological Club November 17, 1938.

The cultural part of this work was undertaken in the plant breeding section of the College of Agriculture Experiment Station grounds. Planting was done from July 1 to 6, 1937, and harvesting, in the later part of July, 1938. The extraction of starch was performed in the cassava starch factory of the College. The whole work covered a period of one cassava growing season, or over twelve months.

MATERIALS AND METHODS

Cassava varieties and their asexual progeny used

The materials used in this study were two bud sports of cassava—one from Java ornamental variety introduced by Dr. N. B. Mendiola into the College cultures and the other from variety Sinkong Manis. The two parent varieties were used as control. To distinguish each parent variety from its asexual progeny, the Java ornamental variety with variegated leaves will be called Variegated variety and its bud sport which has non-variegated leaves Non-variegated sport. The Sinkong Manis which bears curly leaves will be called Curly variety while its bud sport which bears smooth or non-curly leaves, Non-curly sport.

Description

Variegated variety. This variety is commoly known as Java ornamental cassava. The stalks bear leaves with variegated colors. The margin of the leaves are greenish, while the inside part bears from yellow to yellowish white areas. The bud sport of this variety was first reported in 1933 (Mendiola, 1933). It is characterized mainly by the presence of non-variegated or solid green leaves and of stalks darker brown than those of the Variegated variety.

Curly variety. This is another imported variety known in the Philippines as Sinkong Manis. It has curly solid green leaves. The petiole is also greenish. The bud sport of this variety bears non-curly solid green leaves.

Preparation of the field and laying out of the culture

The field used in this work was prepared as for ordinary cassava culture. It was plowed once with a tractor-drawn plow and then three times with native plows drawn by animals at intervals of two to three weeks. Harrowing was done about a week after each plowing.

Each cutting was made about twenty centimeters long and consisting of from fifteen to twenty buds. Care was taken to prevent mixing of cuttings of one group with those of another.

The cuttings were set in rows distanced one meter apart and they were laid singly about ninety centimeters apart in the row. Fifty cuttings were planted in each row. As planting was done when the field was quite wet, the cuttings were set at an oblique position leaving the tips exposed above the surface of the soil.

Rows planted to one bud sport were alternated with rows planted to its mother variety. The Curly variety and its daughter sport were planted in one field, while the Variegated variety and its asexual progeny were grown in another lot. A total of twelve rows were planted to the Variegated variety and ten rows to the Non-variegated sport. In the case of the other lot five rows were planted to the Curly variety and the other five rows to the Non-curly sport.

Care of the culture

The entire culture was given uniform treatment from the time of planting to harvesting. The rows were hilled-up once when the plants were about sixty centimeters tall. Weeding by hoeing was done once when the plants were about a meter high. At the age of about ten months the weeds growing between the rows were cut.

Harvesting

Harvesting was done at the age of twelve months after planting. Stems were cut about thirty centimeters above the ground and then piled at the end of their respective rows. An animal drawn plow passing three times down each row was used in digging the roots. The first furrow was made on one side of the row, the second on the other side, and the third at the center of the row. The roots were collected and piled at the end of each row. The storage roots were separated from the base of the main stalks, the soil clinging to them was removed, and they were weighed. The storage roots obtained from one variety or sport were then hauled to the factory for starch extraction.

OBSERVATIONS

In the field

Observations on the entire culture were made in the field from the time of planting up to harvesting. The characters observed in the field culture were diameter and length of stalks, number of stalks in a hill, occurrence of bud sports, percentage of stand, and weight of storage roots per hill.

Length of stalk was measured from the base to the tip of an average plant in a hill. Diameter of stalk was taken at a point about thirty centimeters above the ground. Average number of stalks per hill was found by dividing the number of all stalks formed by the number of hills counted. That the occurrence of bud sports might be determined, each stalk was examined for the presence of leaves and stalks which were radically different from those of the plants grown.

Percentage of stand was determined by dividing the number of hills that were harvested by the number of cuttings planted and the quotient multiplied by 100 per cent. Weight of roots per hill was found by dividing the weight of all roots obtained by the total number of stools harvested.

In the factory

In the factory, weight of peelings, weight of peeled roots and dried starch extracted from a given amount of roots were taken from each variety or sport. In grating storage roots for extraction of starch, a hand cassava grater, newly devised in the Department of Agronomy and subsequently improved by the writer, was used. From the data obtained the percentage of starch was determined. This was done by dividing the amount of dried starch produced by the weight of roots grated and the quotient multiplied by 100 per cent. The amount of roots and starch obtainable from a hectare of culture was then computed on the basis of 11,100 hills to a hectare spacing plants 100 cm. by 90 cm.; that is, for each variety or sport, 11,100 was multiplied by the percentage of hills reaching maturity and the product multiplied by the average weight of roots produced per hill to obtain the amount of roots available from one hectare. In order to get the amount of starch that might have been obtained from a hectare, the weight of roots calculated from a hectare was multiplied by the percentage of dry starch extracted in a given variety or bud sport.

Hydrocyanic acid present in storage roots produced by the cassava mutant and its parent variety was determined by Mr. Lauro Ynalvez of the Department of Agricultural Chemistry of this College.

RESULTS

The results of this experiment are found in tables 1 to 8 inclusive. Table 1 gives the height of stalks at harvest time, or at the age of twelve months; table 2, the diameter of stalks; table 3, the number of stalks to a hill; table 4, the percentage of stand; table 5, the occurrence of bud sports in the first year of culture; and table 6, the average weight of roots per hill of the bud sports and their parent varieties. Table 7 gives the percentage of starch extracted, and the calculated weights of roots and starch obtainable from a hectare of culture. Table 8 gives the percentage of hydrocyanic acid present in cassava mutants and their parent varieties.

DISCUSSION OF RESULTS

Height of stalks at harvest time

The height of stalks at the age of twelve months (table 1) varied greatly in the two sports of cassava and their parent varieties. The Variegated variety had an average height of 132.9 ± 0.02 cm., while its daughter sport had an average height of 176.8 ± 0.81 cm. The difference in height of stalks of the Variegated variety and its sport was found to be very significant.

When the height of stalks of Curly variety was compared with that of its Non-curly sport, it was also found that the bud sport was significantly taller than its mother. The Curly variety had an average height of 225.4 ± 1.93 cm.; the Non-curly sport, 259.4 ± 1.32 cm.

Size and color of stalks

The size and color of stalks of the bud sports differed from those of their mother varieties. The Non-variegated sport had distinctly deeper brown colored stalks than the Variegated variety. On the other hand the Curly variety had slightly deeper brown colored stalks than its Non-curly sport. As to size of stalks, the Variegated variety produced significantly smaller stalks than its bud sport, the Variegated variety giving an average diameter of only 1.8 ± 0.01 cm.; the sport, 2.4 ± 0.01 cm., (table 2).

In the case of the Curly variety, it was found as shown in table 2 also that the stalks of the bud sport were significantly larger than those of the Curly or mother variety. An average diameter of 3.2 ± 0.03 cm. was computed from 71 stalks of the Non-curly sport; and an average of only 2.8 ± 0.02 cm., from 100 stalks of the Curly variety.

Number of stalks per hill

According to the data in table 3 the Non-variegated mutant had significantly more stalks per hill than its mother variety. The Variegated variety produced an arithmetical average of only 3.0 ± 0.02 stalks to a hill, whereas its Non-variegated progeny had a mean of 3.9 ± 0.01.

In the case of the Curly variety the sport had, on the average, an insignificantly less number of stalks to a hill than its parent. The Curly variety produced an average of 1.9 ± 0.03 stalks per hill; the Non-curly sport, only 1.9 ± 0.01 stalks.

Percentage of stand

Table 4 shows that of the 700 cuttings of the Variegated variety planted, 514 hills, or 73.43 per cent, survived. As to its Non-variegated progeny, 375 hills, or 75.00 per cent of 500 cuttings set out in the field, grew. In the case of the Curly variety, only 85 hills, or 65.60 per cent out of 125 cuttings, reached maturity, whereas the Non-variegated sport gave 111 hills, or 88.89 per cent stand. The wet soil conditions prevailing during planting followed by continuous rain probably caused the death of some of the plants when they were about 30 cm. tall.

Occurrence of bud sports in first year culture

While mutation in cassava may be rare, under certain conditions its occurrence may be more frequent. This is evidenced by observations made on the crop under report and the data presented in table 5. Of 1,016 stalks of the Variegated variety observed, 6 stalks were found bearing Non-variegated leaves. From 158 stalks of Curly variety, 4 stalks bearing Non-curly leaves were found.

Besides the occurrence of the above mutants in the culture of the parent varieties, it was also observed that in the culture of the sports, stalks with the parent variety characteristics were also found. Out of the 1,093 stalks originally grown from cuttings bearing curly leaves, 4 stalks produced variegated leaves.

Of 195 stalks of Non-curly sport, 5 were found bearing curly leaves. It was found that bud sporting occurred oftener among the Curly and Non-curly plants than among the Variegated and Non-variegated ones.

Several tubers with deeper color of skin than the roots ordinarily produced by Non-variegated sport on Variegated variety were found.

Besides these, another sport which was distinctly different from all others was found; this is now under observation.

Yield of storage roots per hill

The average yield of storage roots of the mutant produced per hill was found significantly higher than that of the parent variety (table 6). The 375 hills of the Non-variegated sport gave an average of 1.7 ± 0.03 kgm. of storage roots per hill, whereas its parent variety gave only 0.5 ± 0.02 kgm. to a hill based on 514 hills harvested. In the case of the Curly variety an average yield of 1.0 ± 0.11 kgm. of roots per hill was produced from 85 hills harvested, whereas the Non-curly progeny produced an average of 1.8 ± 0.10 kgm. from 111 hills harvested.

Percentage of starch and the amount of roots and starch obtainable per hectare

As shown in table 7, the mother variety produced less starch than its asexual progeny. The Variegated variety had 17.5 per cent of starch, while its Non-variegated offspring had 20.0 per cent. The Curly variety produced only 12 per cent starch; its Non-curly progeny, 14.5 per cent.

The Non-variegated sport gave a computed yield of 14,152.5 kgm. of roots and 2,830.5 kgm. of dried starch to a hectare, whereas its mother variety gave only 4,319.9 kgm. of roots and 758.0 kgm. of dried starch.

In the case of the Curly variety, a yield of only 6,917.5 kgm. of roots and 830.1 kgm. of dried starch per hectare was obtained as compared to 17,977.6 kgm. of roots and 2,506.8 kgm. of dried starch from a hectare of the Non-curly variety.

Percentage of hydrocyanic acid

The total percentage of hydrocyanic acid present in the storage roots produced by the two cassava mutants is greater than in their parent varieties (table 8). The Non-curly sport had a total of 0.0078 per cent hydrocyanic acid; its parent variety, only 0.0057 per cent. In the case of the Non-variegated sport a total of 0.0114 per cent was found; for the Variegated variety, only 0.0104 per cent. The flesh of the Non-variegated sport has more hydrocyanic acid than its parent variety. In the flesh of the Non-curly sport, a less percentage of hydrocyanic acid was found than in that of its parent variety.

SUMMARY AND CONCLUSIONS

1. This paper reports the results of sporting on two varieties of cassava (*Manihot utilissima* Pohl)—namely, Sinkong Manis and Java ornamental cassava and their asexual progeny.

2. Under the first year of culture, sporting was found more frequent in the Curly variety and its Non-curly mutant than in the Variegated variety and its asexual progeny.

3. The Non-curly and Non-variegated sports produced significantly more storage roots and starch, and larger and longer stalks than did their respective parent varieties.

4. The results of this experiment tend to show that improvement in yield of cassava is possible through selection of bud sports.

LITERATURE CITED

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MENDIOLA, N. B. 1933. A method of plant improvement based on the use of hidden heritable bud variations and those produced through injury. Proceedings of the Society for the Advancement of Research. 1932-1933; 15-57. *Fig. 1-8. Also in* The Philippine Agriculturist 22: 465-508. *Fig. 1–8.*

TABLE 1

Frequency table of height of stalks at harvest time

CLASS VALUE	FREQUENCY OF STALKS		FREQUENCY OF STALKS	
	Variegated variety	Non-variegated sport	Curly variety	Non-curly sport
cm.	*f*	*f*	*f*	*f*
30.5	8	2	—	—
50.5	24	6	—	—
70.5	42	4	—	—
90.5	29	8	1	—
110.5	60	12	0	—
130.5	130	14	2	2
150.5	194	30	7	2
170.5	110	45	2	7
190.5	10	61	7	8
210.5	2	53	6	6
230.5	—	11	20	13
250.5	—	7	29	15
270.5	—	5	6	10
290.5	—	3	3	25
310.5	—	1	—	14
330.5	—	—	—	12
Total	609	262	83	114
Mean height in cm. .	132.9±0.02	176.8±0.80	225.4±0.93	259.4±1.32
Difference between two means	43.9±0.81		34.2±2.35	
Standard deviation in cm.	35.0±0.69	58.0±1.71	41.8±2.12	53.8±2.78
Coefficient of variability in per cent .	20.3±0.40	32.8±0.97	18.5±0.10	20.3±0.14

TABLE 2

Frequency table of diameter of stalks

CLASS VALUE	FREQUENCY OF STALKS		FREQUENCY OF STALKS	
	Variegated variety	Non-variegated sport	Curly variety	Non-curly sport
cm.	*f*	*f*	*f*	*f*
1.05	1	—	—	—
1.25	7	—	—	—
1.45	13	1	—	—
1.65	21	1	3	—
1.85	20	4	3	—
2.05	18	13	2	1
2.25	8	26	1	5
2.45	7	30	15	6
2.65	2	14	23	5
2.85	1	6	19	7
3.05	—	3	12	13
3.25	—	1	15	9
3.45	—	1	6	8
3.65	—	—	1	7
3.85	—	—	—	3
4.05	—	—	—	4
4.25	—	—	—	1
4.45	—	—	—	2
Total	100	100	100	71
Mean diameter in cm.	1.8±0.01	2.4±0.01	2.8±0.02	3.2±0.03
Difference between two means	0.55±0.02		0.39±0.03	
Standard deviation in cm.	0.11±0.01	0.32±0.02	0.42±0.02	0.57±0.03
Coefficient of variability in per cent	6.2±0.29	13.3±0.63	15.1±0.51	18.0±0.08

TABLE 3

Frequency table of number of stalks per hill

CLASS VALUE	FREQUENCY OF STALKS		FREQUENCY OF STALKS	
	Variegated variety	Non-variegated sport	Curly variety	Non-curly sport
No.	*f*	*f*	*f*	*f*
1	106	39	33	51
2	127	54	34	32
3	122	44	14	20
4	95	59	3	5
5	36	32	2	—
6	37	27	—	—
7	6	12	—	—
8	3	11	—	—
9	2	7	—	—
10	0	5	—	—
11	1	—	—	—
12	2	—	—	—
Total	537	290	86	108
Mean	3.0±0.02	3.9±0.01	1.9±0.03	1.9±0.01
Difference between two means	0.84±0.02		0.10±0.03	
Standard deviation .	1.5±0.11	2.0±0.05	0.3±0.01	0.3±0.01
Coefficient of variability in per cent .	50.8±0.81	50.6±0.14	15.1±0.52	15.1±0.68

TABLE 4

Percentage of stand

VARIETY OR SPORT PLANTED	HILLS PLANTED	HILLS HARVESTED AT MATURITY	PERCENTAGE OF HILLS REACHING MATURITY
	number	*number*	*per cent*
Variegated variety	700	514	73.43
Non-variegated sport	500	375	75.00
Curly variety	125	85	65.60
Non-curly sport	125	111	88.89

TABLE 5

Occurrence of bud sports observed under first year of culture

VARIETY OR SPORT PLANTED	TOTAL STALKS EXAMINED	STALKS FOUND AS BUD SPORTS
	number	*number*
Variegated variety	1016	6
Non-variegated sport	1093	4
Curly variety	158	4
Non-curly sport	195	5

TABLE 6

Yield of storage roots per hill of the bud sports and their parent varieties

CHARACTERS STUDIED	VARIEGATED VARIETY		CURLY VARIETY	
	Parent	Non-variegated sport	Parent	Non-curly sport
Number of hills harvested	514	375	85	111
Total weight of storage roots harvested in kilograms ..	271.8	639.8	81.1	202.0
Average weight of storage roots per hill in kilograms ..	0.5±0.02	1.7±0.03	1.0±0.11	1.8±0.10
Difference between two means	1.2±0.01		0.9±0.15	

TABLE 7

Percentage of starch extracted and the estimated weights of storage roots and starch produced per hectare

CHARACTERS STUDIED	VARIEGATED VARIETY		CURLY VARIETY	
	Parent	Non-variegated sport	Parent	Non-curly sport
Percentage of hills reaching maturity.	73.4	75.0	65.6	88.7
Average weight of storage roots per hill in kilograms ..	0.5±0.01	1.7±0.03	0.9±0.11	1.8±0.10
Percentage of starch extracted	17.5	20.0	12.0	14.5
Computed yield of storage roots per hectare in kgm. ..	4,319.9	14,152.5	6,917.5	17,977.6
Computed amount of starch produced per hectare in kgm. ..	758.0	2,830.5	830.1	2,506.7

TABLE 8

Hydrocyanic acid present in cassava mutants and their parent varieties

MUTANT OR PARENT VARIETY PLANTED	HYDROCYANIC ACID FOUND IN:		
	Bark	Flesh	Total
	per cent	*per cent*	*per cent*
Variegated variety	0.0097	0.0007	0.0104
Non-variegated sport	0.0089	0.0025	0.0114
Curly variety	0.0048	0.0009	0.0057
Non-curly sport	0.0070	0.0008	0.0078

EFFECTS OF VARYING AMOUNTS OF AMMONIUM SULFATE ON MOISTURE CONTENT OF LIPA CLAY LOAM AT WILTING OF RICE PLANTS[1]

FELIPE R. LOPEZ

This work was undertaken as part of a series of studies on effects upon rice plants of varying amounts of ammonium sulfate. The present paper reports data on moisture contents of Lipa clay loam at the time of wilting of the leaves of rice of different ages when supplied with varying amounts of ammonium sulfate.

Review of literature

The first report in the Philippines on this subject was that from the Department of Agricultural Botany by Serrano (1938). Upland rice plants of different ages were used without fertilizer; it was found that as the rice plants grew older, their leaves wilted in the presence of more and more moisture in Lipa clay loam. The moisture content ranged from 20.38 to 14.45 per cent with 30-day old plants, 22.2 to 16.75 per cent with 60-day old plants, and 24.57 to 19.44 per cent with 90-day old plants.

Serrano (1938) further noted that the higher the temperature of the air, the greater was the percentage of moisture that the plant was unable to extract from the soil before wilting. She, likewise, noted that relative atmospheric humidity did not have a decisive influence on the amount of water that the plant was unable to extract from Lipa clay loam.

Briggs and Shantz (1912) found that the finer the soil particles the greater was the amount of water that remained in the soil at the time of permanent wilting. They also found that the wilting coefficient of a given soil was constant regardless of climatic condition prevailing at the time of wilting and of the kind of plant.

Brown (1912), however, found that the rate of evaporation previous to the time of wilting seemed to determine the percentage of moisture that the plant could not extract from the soil. Brown's work was confirmed by Caldwell (1913), who states that for a series of plants grown in a soil and allowed to wilt under a number of aërial conditions, as many different soil moisture contents were obtained as there were different aërial conditions. Similar results were obtained by Shive and Livingston (1914), who report that the amount of water that remained in a soil when a plant permanently wilted was influenced by the atmospheric conditions that prevailed previous to the time of wilting.

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[1] Experiment Station contribution No. 1318. Prepared in the Department of Agricultural Botany under the direction of Professor Rafael B. Espino.

Weaver (1926) states that the roots that came in contact with a fertilizer layer developed abundantly and profusely, but that the vertical penetration of the roots into the soil was retarded. Espino and Borja (1935) reported that in Luzon White sugar cane, the plants in the fertilized cultures wilted earlier than those in the corresponding unfertilized ones. The plants in the fertilized cultures, however, recovered earlier from wilting and, as a whole, became more thrifty than those in the corresponding unfertilized cultures.

Objects of this study

The objects of this study were to determine the moisture content of Lipa clay loam in pots during wilting of leaves of upland rice, variety Inintiw, as influenced (*a*) by varying amounts of ammonium sulfate, (*b*) by age of plant, and (*c*) by certain data obtained at the time of harvest.

Time and place of this study

The pot cultures were set out in the experimental yard of the Department of Agricultural Botany from March, 1938, to September, 1938.

MATERIALS AND METHODS

The plant

The Inintiw rice seeds, obtained from the Department of Agronomy, were soaked in water for thirty-six hours and planted in pots at the rate of four to each. When the seedlings were one week old, some were pulled out, and only two which were apparently uniformly developed and healthy were left in each pot.

The soil

Lipa clay loam, taken from a lot in the Rural High School reservation, was used. It was pulverized, sifted, and mixed thoroughly. The N, P_2O_5, and K_2O contents of the soil were determined by the

Department of Agricultural Chemistry and found to be 0.13 per cent N, 0.20 per cent P_2O_5, and 0.37 per cent of K_2O.

The fertilizer

Ammonium sulfate with 20.6 per cent N was applied in varying amounts at the time of planting. In the first series, it was applied at the rates of 10, 8, 6, 4, and 2 grams per pot. Each culture was run in quadruplicate. In the second series, the fertilizer was applied at the rates of 14, 12, 10, 8, 6, 4, and 2 grams per pot. Each culture was run in triplicate. Unfertilized cultures were included in both series to serve as control.

Pots used

Owing to the lack of pots of uniform type or size, those used in this study were of two types. The larger ones were ordinary petroleum tins cut into halves. Ninety-six pots of this type, each containing 7.0 kgm. of air-dry soil, were used. In the second series 96 glazed earthen pots with a diameter of 21.5 cm. each were used. Six kilograms of air-dry soil were placed in each of these pots.

Cultures

Two series of pot cultures were tried. The first series consisted of four sets of cultures, each of which consisted of six quadruplicate cultures. In set I, the panicles were allowed to mature and the grains were harvested. In sets II, III, and IV, the cultures were employed for the determination of the moisture content of the soil. The cultures in set II were allowed to wilt when the plants were in the seedling stage, or were nineteen days of age. The plants in set III were allowed to wilt during their vegetative stage, or when they were about forty-five days old. The plants in set IV were allowed to wilt during their flowering stage. The second series consisted also of four sets of cultures, but each set included eight triplicate cultures.

The cultures in the first series were started on March 1, 1938. Nineteen days later, those in set II (seedling stage) were placed in the shade and deprived of water. After about thirteen days, the plants began to show signs of wilting. Observations on the behavior of the leaves were made, soil samples were taken, and afterwards the cultures that had signs of initial wilting of the leaves were placed in the damp chamber for twenty-four hours. Then the plants were removed, and the leaves were observed again to note any signs of recovery from wilting. Six cultures at a time, each in quadruplicate or triplicate, were used for observation.

The cultures in set III (vegetative stage) were kept outside until the plants were forty-five days old. Then they were placed in the shade and deprived of water, as in set II. After five days, they showed signs of wilting. Observations were also made on the behavior of the leaves before and after being put in the damp chamber. The number of cultures placed in the damp chamber for observation day by day depended upon the number of plants that showed signs of wilting, as they did not wilt at the same time. The cultures that received larger amounts of fertilizer wilted earlier than the less fertilized one, and much more than the control.

The cultures in set IV were kept outside, directly exposed to the sun, until the plants were sixty-four days of age, when they began to produce flowers. Then the plants were placed in the shade and deprived of water. In this set, as in set III, the differently treated cultures did not wilt at the same time. Those that received high applications wilted earlier than those that received low applications; hence, the number of plants that were placed in the damp chamber for observation depended also upon the number of cultures that wilted.

The cultures in set I were grown to maturity for the harvest of grains and straw.

The second series was conducted from May, 1938, to September 11, 1938. As in the first, this series consisted of four sets of cultures, each one of eight triplicate cultures. The procedure followed in this series was practically the same as that followed in the first series.

Care of cultures

The cultures were grown in the open exposed to direct sunlight. They were watered, weeded, and cultivated as often as necessary. Care was taken to keep them free from insects and birds.

Moisture content of Lipa clay loam at wilting of rice plants

As soon as the plants showed signs of wilting, soil samples were taken by means of a cork borer which was driven into the soil to the bottom of the pot. Each sample was placed in a separate envelope and weighed in an analytical balance. After being weighed, the samples were dried to constant weight in an electric oven at a temperature of 100°C. and the percentage of moisture in the soil was determined.

Other criteria of results

In addition to the percentage of moisture in the soil, the number of bearing and non-bearing culms, dry weight of tops, dry weight of empty and full grains, external appearance of the plants, number of dry and green leaves were recorded.

Number of bearing and non-bearing culms. At maturity of the plants, the average number of bearing and non-bearing culms produced by the two rice plants in each pot was determined.

Dry weight of tops. After the panicles were harvested, the straw from each culture was cut close to the roots, bundled, labeled, dried first in the sun and then in the electric oven to a constant weight, and weighed.

Dry weight of empty and full grains. The harvested panicles from each culture were placed in paper bags properly labeled and were dried in the sun. The grains from each culture were shattered, placed back in the paper bags, and weighed.

External appearance of plants. The external appearance of the plants in the different cultures was noted at (*a*) seedling stage, (*b*) vegetative stage, and (*c*) flowering stage. A final observation was made at the time of harvest.

Number of dry and green leaves. In set IV of the second series, the number of dry and green leaves was counted and recorded from day to day just before the wilted plants were put in the damp chamber. The number was only approximate since some of the leaves had already been destroyed.

EXPERIMENTAL DATA

The experimental data are recorded in tables 1 to 6. Table 1 contains, in percentage, the average moisture contents of the Lipa clay loam at the time of wilting of the leaves of the rice plants in the seedling, in the vegetative, and in the flowering stages. In this table are also shown the temperature and relative humidity of the air.[2] Harvest data obtained from a set of cultures included in the first series are recorded in table 2.

In the second series, the average percentage of moisture of Lipa clay loam at the time of wilting of the leaves of the rice plants in the seedling, in the vegetative, and in the flowering stages are given in table 3. The table also includes temperature and relative humidity of the air.

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[2] Weather data were obtained from the files of the Department of Agricultural Botany.

Harvest data from a set of cultures included in the second series are recorded in table 4. Table 5 shows the average moisture content of the soil at the time of wilting of the leaves of the rice plants at the flowering stage together with the average number of the dry and the green leaves of the plants in the different cultures.

The moisture contents of the soil at the time all the leaves of the rice plants in their three developmental stages were permanently wilted are recorded in table 6.

DISCUSSION OF RESULTS

General observations

It was noted that although the older leaves were decidedly dry, the youngest leaf or a small group of younger leaves was still green. In advanced stage of wilting, the leaves became completely rolled, drooping, and dry in appearance. When the plants were permanently wilted, the leaves could not recover the state of turgidity even when placed in the damp chamber for twenty-four hours. These observations confirmed Serrano's (1938) report.

Decrease of moisture content of Lipa clay loam during the period of wilting [3]

The moisture contents of the soil in table 1 in the first series and in table 3 in the second series of cultures were for the different stages of wilting of the leaves of the rice plants of different ages. Under the conditions of this study, the wilting period for all the leaves in a pot was from six to thirteen days. Serrano (1938) found, however, that the wilting period lasted only from four to five days. But, as in Serrano's cultures, the difference between the moisture content of the soil when wilting began and when all the leaves were permanently wilted was very variable. Moreover, confirming Serrano's finding, as shown in tables 1 and 3, the rates of decrease of moisture content of the Lipa clay loam in pots from day to day in the shade during the period of wilting were gradual and slight.

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[3] By period of wilting is here meant the number of days that elapsed from the initial wilting to permanent wilting of the leaves.

Moisture content of Lipa clay loam during the wilting of leaves of rice plants of different ages

Tables 1 and 2 show that, owing to differences in dates and in the amount of ammonium sulfate applied, the data from the different sets of cultures in which the rice plants were at seedling, vegetative, or flowering stages are not quite comparable. In terms of average, however, comparison of the data for the three developmental stages of the plants shown in these tables becomes feasible, provided the comparison only of the average data obtained from each culture type is made. Following this scheme, the data in tables 1 and 3 plainly show that as the upland rice plants grew older, wilting occurred in the presence of more and more moisture in Lipa clay loam in the pots, confirming the findings of Serrano (1938).

The average data, however, referred to and shown in tables 1 and 3 are probably good only for showing, in a general way, the amounts of moisture that were left in the soil during the period of wilting of the leaves of the plants of different ages. The data under a better criterion for comparison may be seen in table 6. In this table are shown the actual and average moisture contents of the Lipa clay loam at the time all the leaves of the rice plants in the different cultures were permanently wilted. These data also show that under the same or a similar culture number, the leaves of the plants at their seedling stage permanently wilted with the moisture contents in the pots ranging from 14.33 to 14.39 per cent by weight. The leaves of the rice plants in their vegetative stage wilted permanently in the presence of more soil moisture, ranging from 15.63 to 16.97 per cent. The leaves of the older plants (flowering stage) wilted permanently in the presence of still more soil moisture, which ranged from 17.87 to 19.54 per cent. In view of these findings, it may again be concluded that as the rice plants grew older, permanent wilting of all the leaves occurred in the presence of more and more moisture in Lipa clay loam.

Moisture content of Lipa clay loam during the wilting of rice as influenced by varying amounts of sulfate of ammonia

Tables 1 and 2 show that no definite or consistent trend of variations seemed to occur in the moisture contents of the soil when supplied with varying amounts of ammonium sulfate at the time of the wilting of the rice plants at their seedling stage. During the latter stages, however, the moisture content of the soil at the time of wilting seemed to increase only in a rather moderate way as the amount of the fertilizers used was increased.

Probably a more rational appraisal may be made, however, when (*a*) the data as averages during the period of wilting and (*b*) the moisture contents of the soil when all the leaves of the rice plants were permanently wilted are considered. In the first case, the figures are shown in tables 1 and 3, and in the second, in table 6. As shown in table 1, during the seedling stage of the plant, the average moisture contents of the soil in the different cultures during the period of wilting ranged only from 14.97 to 14.99 per cent. During the vegetative stage, however, the range was a little wider, from 16.71 to 17.59 per cent, whereas during the flowering stage of the plant, the amounts of water that were left in the soil during the period of wilting of the plant leaves ranged from 18.59 to 19.85 per cent. In each of the three cases, the highest moisture content was always obtained from the soil that received the largest application of the fertilizer tried and the lowest moisture content was obtained from culture II which received the smallest amount of ammonium sulfate.

These results are also borne out by the data in table 3. In this table, the range of the moisture content of the soil for the seedling stage was from 15.34 to 15.35 per cent; that for the vegetative stage of the plant, 15.53 to 16.80 per cent; and that for the flowering stage, 17.73 to 19.77 per cent. The range of variations in moisture contents of the soils in each set of cultures that received varying amounts of ammonium sulfate was rather narrow. Moreover, the difference between the average moisture content of the soil in any one culture with that in the soil in the next culture was always very little. For these reasons, it may be concluded that varying the application of ammonium sulfate to Lipa clay loam did not materially alter the amount of water which the rice plants failed to absorb from the soil at the time of wilting of their leaves.

Table 6 shows that whether the soil was fertilized or not, in the cultures that received identical treatments, the older rice plants wilted permanently, leaving in the soil relatively more moisture than in that in which the younger plants were grown. In other words, whether fertilized with ammonium sulfate or not, more moisture was always left unabsorbed from the soil by the older than by the younger rice plants at the time when all their leaves had reached the stage of permanent wilting. The data in table 6 also show that, with the exception of the rice plants in the seedling stage and culture II which received the lowest application of the fertilizer used, the fertilized cultures always had more moisture in the soil unabsorbed at the time of permanent wilting of the plants. And, during the vegetative and the flowering stages of the plants, the amount of water that was left unabsorbed from the soil at the time of permanent wilting of the leaves seemed to increase with the application of the fertilizer.

Influence on the wilting of rice by temperature and humidity of air

The data in tables 1 and 2 seem to show that no direct correlation exists between the amount of moisture left in the soil at the time of wilting and the air temperature and relative humidity of the air. The reason for this was that the moisture in the pot cultures was allowed to evaporate continually and be absorbed by the plants until permanent wilting of the leaves was attained. Obviously under the circumstances, soil moisture in each culture kept on decreasing irrespective of the variations in the air temperature and in the relative humidity of the air; hence, the apparent lack of correlation and the failure of the data on hand to confirm Serrano's findings.

Relation between yield and amount of moisture left in the soil as influenced by variations in ammonium sulfate

Tables 2, 4, and 6 reveal that no direct and consistent correlation seemed to exist between the moisture content of the soil in the different cultures at the time of permanent wilting of the leaves and any of the harvest data obtained. In a general way, however, the cultures that gave relatively high harvest data on (*a*) number of bearing culms, (*b*) dry weight of top, and (*c*) dry weight of grain were the very ones that had relatively large amounts of moisture in the soil not absorbed by the roots of the rice plants at the time of permanent wilting. Of course, the reason for this apparent relationship goes back to certain amounts of the fertilizer that had been applied; these in turn, were responsible for the increase in harvest data and for the relatively rapid transpiration which ultimately brought about the comparatively early permanent wilting of the leaves of the plants.

Moisture content of Lipa clay loam at the wilting period of flowering rice plants compared with the number of dry and fresh leaves produced

Table 5 shows that the average moisture content of the soil seemed to vary, although gradually and probably within certain limits, with the amount of the fertilizer used. These data, placed side by side in table 5 with those on the number of dry and fresh leaves of the plants from the different cultures, reveal the fact that they have relation with the number of leaves produced. In a general way, it can tentatively be said that the greater the application of ammonium sulfate, the greater was the amount of water left in the soil at the time of wilting and the greater the number of leaves produced.

SUMMARY AND CONCLUSIONS

1. The leaves of rice, variety Inintiw, grown on Lipa clay loam in pots and supplied with varying amounts of sulfate of ammonia did not wilt at the same time.

2. The difference between the moisture content of the soil when the leaves began wilting and when all the leaves were permanently wilted was very variable.

3. During the period of wilting the daily decrease of moisture content of Lipa clay loam in pots in the shade was gradual and slight.

4. As the plants grew older, more and more moisture was left in Lipa clay loam in pots at the time of wilting. This condition was obtained in both the fertilized and the unfertilized sets.

5. There seems to be no definite or constant trend of variation in the moisture content of the soil when supplied with varying amounts of ammonium sulfate at the time of the wilting of the rice plant leaves at their seedling stage.

6. Varying the application of ammonium sulfate to Lipa clay loam did not materially alter the amount of water which the rice plants in their seedling stage failed to absorb from the soil at the time of permanent wilting of the leaves.

7. During the vegetative and the flowering stages of the plants, the amount of water that was left in the soil at the time of permanent wilting of the leaves seemed to increase with the application of ammonium sulfate fertilizer.

8. In a general way, the cultures that gave high harvest data on number of bearing culms, dry weight of top, and dry weight of grain were the very ones that had relatively large amounts of mois-

ture in the soil not absorbed by the roots of the rice plant at the time of permanent wilting.

9. In a general way again, it can be said that the greater the application of ammonium sulfate the greater was the amount of water that was left in the soil at the time of wilting, and the greater was the number of leaves, fresh and dry, produced by the rice plants.

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TABLE 1

Average moisture contents of Lipa clay loam at different stages of development of rice plants at the time of wilting of leaves[a]
(Experiments from March 1, 1938, to June 23, 1938)

CULTURE NO.	AMMONIUM SULFATE USED		SEEDLING STAGE		VEGETATIVE STAGE		FLOWERING STAGE	
			Dates sampled	Average soil moisture	Dates sampled	Average soil moisture	Dates sampled	Average soil moisture
	grams	*ton/ha.*	*1938*	*per cent*	*1938*	*per cent*	*1938*	*per cent*
I	0	0	April 1-12	15.023	April 24-May 2 .	16.300	May 23-31	17.762
II	2	1/4	*do*	14.976	April 18-25	16.711	May 21-30	18.590
III	4	1/2	*do*	14.985	April 18-23	17.080	May 19-27	19.475
IV	6	3/4	*do*	14.978	*do*	17.460	May 19-27	19.636
V	8	1	*do*	14.999	*do*	17.53	May 19-26	19.852
VI	10	1 1/4	*do*	14.999	*do*	17.595	May 19-26	19.858
			Av. air temp. 26.55°C. Av. relative humidity of air 72.36 per cent.		Av. air temp. 29.06°C. Av. relative humidity of air 62.5 per cent.		Av. air temp. 27.6°C. Av. relative humidity of air 69.1 per cent.	

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[a] Compiled from longer tables on file in the Department of Agricultural Botany.

TABLE 2

Average data obtained from fully matured rice plants[a] *grown in Lipa clay loam in pots in which varying amounts of ammonium sulfate fertilizer were used*

(Experiment from March 1, 1938, to June 23, 1938)

CULTURE NO.	AMMONIUM SULFATE USED		NUMBER OF CULMS		DRY WEIGHT		EXTERNAL APPEARANCE
			Bearing	Non-bearing	Top	Grains	
	grams	*ton/ha.*			*grams*	*grams*	
I	0	0	12.77	2.00	26.74	18.04	Plants stunted; leaves few, quite narrow, yellowish green
II	2	¼	24.5	2.00	48.95	32.53	Plants quite normal; leaves greenish
III	4	½	26.75	1.25	68.24	38.08	Plants of fair growth; leaves green
IV	6	¾	31.00	2.25	73.65	39.51	Plants of good growth, leaves green
V	8	1	29.5	13.75	83.45	32.33	Plants of vigorous growth, leaves dark green, broad
VI	10	1¼	24.75	15.25	85.87	25.72	Same as above

[a] Two plants in each pot.

TABLE 3

Average moisture contents of Lipa clay loam at different stages of development of rice plants at the time of wilting of leaves[a]
(Experiments from May 2, 1938, to September 8, 1938)

CULTURE NO.	AMMONIUM SULFATE USED		SEEDLING STAGE		VEGETATIVE STAGE		FLOWERING STAGE	
			Dates sampled	Average soil moisture	Dates sampled	Average soil moisture	Dates sampled	Average soil moisture
	grams	*ton/ha.*	*1938*	*per cent*	*1938*	*per cent*	*1938*	*per cent*
I	0	0	May 31-June 12 .	15.343	July 3-10	15.69	August 14-24	17.59
II	2	1/4	*do*	15.356	June 24-July 4 ..	15.536	August 11-19	17.73
III	4	1/2	*do*	15.344	June 21-July 4 ..	16.052	August 8-16	19.13
IV	6	3/4	*do*	15.343	June 21-27	16.585	August 6-13	19.23
V	8	1	*do*	15.352	*do*	16.637	*do*	19.61
VI	10	1 1/4	*do*	15.352	*do*	16.712	*do*	19.66
VII	12	1 1/2	*do*	15.356	*do*	16.737	*do*	19.79
VIII	14	1 3/4	*do*	15.356	*do*	16.807	*do*	19.77
			Av. air temp. 27.4°C. Av. relative humidity of air 70.5 per cent.		Av. air temp. 27.3°C. Av. relative humidity of air 70.83 per cent.		Av. air temp. 28.27°C. Av. relative humidity of air 61.63 per cent.	

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[a] Compiled from longer tables on file in the Department of Agricultural Botany.

TABLE 4

Average data obtained from fully matured rice plants[a] grown in Lipa clay loam in pots in which varying amounts of ammonium sulfate fertilizer were used

(Experiment from May 2, 1938, to September 8, 1938)

CULTURE NO.	AMMONIUM SULFATE USED		NUMBER OF CULMS		DRY WEIGHT		EXTERNAL APPEARANCE
			Bearing	Non-bearing	Top	Grains	
	grams	*ton/ha.*			*grams*	*grams*	
I	0	0	4.40	1.2	15.6	8.13	Plants stunted; leaves few, yellowish green
II	2	¼	14.60	2.00	36.0	11.7	Plants normal; leaves greenish
III	4	½	20.45	3.15	68.0	21.8	Plants fair; leaves green
IV	6	¾	24.0	2.6	71.6	24.8	Same as III
V	8	1	23.6	5.0	72.3	20.5	Plants of good growth; leaves green
VI	10	1¼	26.39	4.21	77.6	20.7	Same as III
VII	12	1½	22.30	9.00	82.8	17.0	Plants of vigorous growth; leaves many, dark green
VIII	14	1¾	20.60	18.00	90.3	15.17	Plants of vigorous growth; leaves many, broad, dark green

[a] Two plants in each pot.

TABLE 5

Data obtained from rice plants[a] *at flowering stage grown in Lipa clay loam in pots to which varying amounts of ammonium sulfate fertilizer were added*

CULTURE NO.	AMMONIUM SULFATE USED		AVERAGE SOIL MOISTURE	AVERAGE NUMBER OF LEAVES		TOTAL
				Dry	Green	
	grams	*ton/ha.*	*per cent*			
I	0	0	17.59	34.4	10.9	45.3
II	2	1/4	17.73	52.1	21.1	73.2
III	4	1/2	19.08	61.0	20.5	81.5
IV	6	3/4	19.02	74.1	29.4	103.5
V	8	1	19.48	77.3	38.1	115.4
VI	10	1 1/4	19.51	71.1	35.8	106.9
VII	12	1 1/2	19.64	83.5	32.4	115.9
VIII	14	1 3/4	19.63	81.5	35.0	116.5

[a] Two plants in each pot.

TABLE 6

Moisture contents of Lipa clay loam at the time all the leaves in the different cultures were permanently wilted,[a] *in per cent*

CULTURE NO.	AMMONIUM SULFATE USED		SEEDLING STAGE		VEGETATIVE STAGE		FLOWERING STAGE		AVERAGE			AVERAGE
			a	b	a	b	a	b	Seedling stage	Vegetative stage	Flowering stage	
	gr./pot	*ton/ha.*										
I	0	0	14.32	14.38	15.89	15.57	18.57	17.30	14.35	15.73	17.93	16.00
II	2	1/4	14.29	14.39	15.92	15.34	18.28	17.47	14.34	15.63	17.87	15.95
III	4	1/2	14.31	14.40	16.72	15.98	18.53	18.87	14.35	16.35	18.70	16.47
IV	6	3/4	14.33	14.37	17.21	16.45	19.49	18.90	14.35	16.83	19.19	16.79
V	8	1	14.31	14.36	17.36	16.48	19.57	19.31	14.33	16.92	19.44	16.89
VI	10	1 1/4	14.31	14.39	17.43	16.51	19.61	19.41	14.35	16.97	19.51	16.94
VII	12	1 1/2	—	14.40	—	16.61	—	19.54	14.40	16.61	19.54	16.85
VIII	14	1 3/4	—	14.39	—	16.65	—	19.51	14.39	16.65	19.51	16.85

[a] Compiled from longer tables on file in the Department of Agricultural Botany.

COLLEGE AND ALUMNI NOTES

Mr. Marcelo Crisostomo, B.S.Agr. '13, died of heart attack on July 24, 1939, at La Castellana, Negros Occidental, leaving a wife and several children. Although Mr. Crisostomo had been Spanish-educated and he spoke very little English when he entered the College, he proved himself a very useful man. He was the first College librarian and toolkeeper, and he proved himself a handy man during his undergraduate days in several other ways.

Dr. Edwin R. Helwig, assistant professor of zoölogy, University of Pennsylvania, visited the College on July 25 while passing through Manila on his way home from South Africa and Java. Dr. Helwig was travelling with Professor C. E. McClung, director of the zoölogical laboratories of the same University, and Mrs. McClung. The Department of Entomology here coöperated with them by securing grasshopper material for cytological purposes.

Two Japanese students from the Tokyo University of Commerce, Messrs. Kohzou Nakamura and Jinei Tanaka, visited the campus on July 28, accompanied by a representative from Madrigal and Company. These students were touring the Philippines as guests of Mitsui Bussan Kaisha, Ltd.

A Japanese students' goodwill party under the sponsorship of the Osaka Mainichi and the Tokyo Nichi-Nichi newspapers visited the College on August 3. The party consisted of forty-five university and college students and was headed by Mr. Kennosuke Sato, chief of the international section of the Osaka Mainichi and Mr. Zembei Uehara, of the Philippine Society of Japan in Osaka.

A basketball game between U. P. Manila and U. P. Los Baños was played before a capacity crowd at Baker Hall on August 6. The game was furiously contested from the outset to the final whistle, ending with the score of 30 to 25 in favor of the Manila team.

EXTERNAL ANATOMY AND DIAGNOSTIC CHARACTERS OF SOME COMMON PHILIPPINE WHITE GRUBS [1]

GETULIO B. VIADO
Of the Department of Entomology

WITH TEN PLATES

The earliest available records on white grubs affecting field crops in the Philippines are those of Sanchez (1894) and Alcarraz (1895). Sanchez stated that, in the Visayas, the *bucán*, which he misidentified as *Melolontha villosa*, had been causing great destruction to sugar cane for many years. In the Ilocos region, Alcarraz made investigations on the habits of *abal-abal* (local name of *Lepidiota* and *Leucopholis* in some parts of the Ilocos region) grubs attacking sugar cane, garden crops, cotton, corn, and many other crops. He claimed that the *abal-abal* consisted of two species, *Melolontha vulgaris* and *Melolontha villosa*.

Stanton (1903) reported grubs of *Leucopholis irrorata* Chevr., *Anomala anoguttata* Burm. and a cetoniid he identified as *Cetonia mandarina* as feeding on the roots of various young trees and shrubs. Uichanco (1928, 1930a, and 1931) recorded white grubs as injurious to sugar cane in various localities in Luzon and Negros. Otanes (1927) stated that he first noted the grub of *Leucopholis irrorata* Chevrolat on sugar cane in October, 1923, in Balayan, Batangas, and in some parts of Zambales, Philippine Islands. In both regions the grub was injurious to sugar cane. In an earlier paper (Otanes, 1924), this same writer, during the root grub outbreak in 1923, noted the grub of this species to be very destructive to sugar cane and upland rice in Batangas. It must be noted that, of the species of *abal-abal* studied by Alcarraz (1895), at least one which produces grubs that attack sugar cane and other crops is identical with *Leucopholis irrorata* Chevrolat. This species together with a species of *Lepidiota* (probably *blanchardi*) is the most common and widely distributed scarabaeid affecting cultivated plants in the Ilocos region. Information from old farmers in the province of Abra reveals that

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[1] Experiment Station contribution, No. 1319. Prepared in the Department of Entomology under the direction of Professor Leopoldo B. Uichanco.

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these species now present in this province are identical with those that had been found there long before American occupation. In some parts of Ilocos Sur and La Union provinces, the name *abal-abal* is applied to both *Leucopholis* and *Lepidiota,* but in Abra and Ilocos Norte the term *abal-abal* is restricted to *Lepidiota;* and to *Leucopholis* is given the name *aros-aros.*

Copeland (1917) stated that *Holotrichia vidua* Sharp is recognized as a serious enemy of sugar cane in the Philippines as well as in Java. Woodworth (1921) in a host index of insects injurious to Philippine crops mentioned *Holotrichia vidua* Sharp as the only scarabaeid insect pest of sugar cane. Uichanco (1928) reported the grubs of the following scarabaeids as affecting the cane roots: *Alissonotum pauper* Burmeister, *Adoretus luridus* Blanchard, *Anomala humeralis* Burmeister, *Anomala sulcatula* Burmeister, *Leucopholis irrorata* Chevrolat, *Holotrichia vidua* Sharp, and two species of *Autoserica.* In the Victorias area, Negros Occidental, Pierce (1930) reported eight species of scarabaeid grubs as destroying sugar cane roots. Uichanco (1931) stated that the most important sugar cane grub in the Philippines was *Leucopholis irrorata* Chevrolat. Otanes (1924) reported the grubs of *Leucopholis irrorata* Chevrolat, as feeding on the roots of sugar cane, corn, rice, Guinea grass, mango, santol, the cannas, pineapple, water melon, and peas.

The importance of white grubs as a pest is shown by the numerous researches conducted on this species in the Philippines.

Uichanco (1931) found that the average larval period of *Leucopholis irrorata* Chevrolat is 289.5 days. According to Pierce (1930) several distinct species responsible for grub injury in Negros require many months, sometimes over a year, for their development. White grubs of the family Scarabaeidae have so many characteristics in common that one species is often mistaken for the other, especially in the case of grubs of the same genus where the diagnostic characters are often confused because of their very close similarity. Although size is a fairly good criterion in distinguishing mature grubs of the larger beetles like the *Lepidiota* and *Leucopholis* from those of the smaller beetles (*Adoretus*, *Autoserica*, etc.), it does not enable one to definitely identify the grub, especially when dealing with a wide range of specimens.

So far as the writer knows, no work on white grub morphology and taxonomy has as yet been done in the Philippines. Attempts were made by Otanes (1924) to distinguish the grub of *Leucopholis* *irrorata* Chevrolat from other grubs, using as a basis the arrangement of the setae at the venter of the anal segment of the grub, and by Pierce (1930) who, using the spiracles as criterion, identified grubs of different species.

Objects of the present work

The objects of the present work were: (*a*) to study the comparative external anatomy of larvae of *Leucopholis irrorata* Chevrolat and *Lepidiota blanchardi* Dalla Torre, and (*b*) to determine the principal diagnostic characters of the commoner white grubs affecting Philippine field crops.

Time and place of the present study

This work covered a period of a little over two years, from April, 1930, to May, 1932. Most of the work was done in the laboratory and at the insectary of the Department of Entomology. Observations and collections of adult beetles were made in the field.

MATERIALS AND METHODS

Species used

- Order Coleoptera
  - Family Scarabeidae
    - Subfamily Melolonthinae
      - *Leucopholis irrorata* Chevrolat
      - *Lepidiota blanchardi* Dalla Torre
      - *Stephanopholis philippinensis* Brenske
      - *Holotrichia flachi* Brenske
    - Subfamily Sericinae
      - *Autoserica nigrorubra* Brenske
    - Subfamily Rutelinae
      - Tribe Anomalini
        - Genus Anomala
          - Subgenus Anomala
            - *Anomala humeralis* Burmeister
    - Subfamily Adoretinae
      - Tribe Adoretini
        - *Adoretus luridus* Blanchard
        - *Adoretus ranunculus* Burmeister

Collection of adults and rearing for larval stage

Preliminary observations were made on plants in the vicinity of the College campus for any suspicious signs of beetle attack on the leaves. These were made about the middle of May, 1930, after the first heavy rains. After the attacked plants were located, they were examined at night with the aid of a lantern for the species of beetles needed for the work. Also, collections were made around electric light bulbs at night.

The following were the host plants of the beetles collected in Los Baños:

- Order Geraniales
  - Family Euphorbiaceae
    - *Acalypha wilkesiana* Muell.-Arg.
      - *Adoretus luridus* (very abundant)
      - *Anomala humeralis* (abundant)
      - *Holotrichia flachi* (very few)
      - *Autoserica nigrorubra* (few)
- Order Parietales
  - Family Flacourtiaceae
    - *Flacourtia ramontchi* L'Hérit.
      - *Adoretus luridus* (very abundant)
      - *Anomala humeralis* (abundant)
- Order Myrtiflorae
  - Family Lythraceae
    - *Lagerstroemia indica* Linn.
      - *Adoretus luridus* (very abundant)
- Order Rosales
  - Family Rosaceae
    - *Rosa* spp. (cultivated varieties)
      - *Adoretus luridus* (abundant)
      - *Adoretus ranunculus* (few)
  - Family Leguminosae
    - *Tamarindus indica* Linn.
      - *Adoretus luridus* (abundant)

Around electric light bulbs adults of *Holotrichia vidua* Sharp, *Adoretus luridus* Blanchard, *Adoretus ranunculus* Burmeister, *Anomala humeralis* Burmeister, and *Holotrichia flachi* Brenske were collected.

Each species of beetles collected was confined separately in battery jars which contained moist soil four to five centimeters deep. Cut stems with leaves of their host plant species were regularly made available to the beetles. The soil in the battery jars was examined daily for eggs. The eggs were isolated in similar jars containing rich soil. The grubs on hatching were supplied with split stalks of sugar cane. As the grubs grew larger they were confined individually in tin cans containing soil and feed. The grubs were examined every other day, and care was taken that the soil was moist. Some of the grubs were reared to prepupa to determine the maximum size attained by the grubs. During the course of the observation none of the grubs reared were found feeding on the fresh cane stalk supplied. It was only when the feed disintegrated that the grubs paid attention to it.

Of all the species collected and reared, only *Adoretus luridus, Adoretus ranunculus, Anomala humeralis,* and *Autoserica nigrorubra* could be induced to lay eggs: *Holotrichia vidua* and *Holotrichia flachi* laid no eggs, despite the abundance of adults collected.

Preparation of materials for study

When the grubs had attained their maximum size (at the last, or third, larval instar), they were preserved by first being fixed in hot water at about 90°C for thirty minutes, then quickly cooled on ice for another thirty minutes, and finally transferred to 80 per cent alcohol. To facilitate the penetration of alcohol inside the body, the grubs were pricked three or four times on various parts of the body. In the preparation of anatomical parts for slide mounts, the grubs were macerated in 4 per cent aqueous solution of potassium hydroxide and then thoroughly washed with water. The parts to be mounted were then dissected out, stained with Gage's aceto-carmine and passed through three grades of alcohol (80 per cent, 95 per cent, and absolute) then through carbol-xylene and finally through pure xylene. From xylene the specimens were mounted in balsam.

COMPARATIVE MORPHOLOGY OF LARVAE OF LEUCOPHOLIS IRRORATA AND LEPIDIOTA BLANCHARDI

Head and mouth parts

Head. Anterior aspect of head: Leucopholis irrorata. (Pl. 1, fig. 2). Head roughly hemispherical, light brown, measuring about 5.3 mm. from back of head to fronto-clypeal suture, 8.0 mm. wide. Divided into three sclerites by inverted roughly Y-shaped or fork-shaped epicranial suture. Stem of fork depressed at about point of branching; branches even with surface of cranium. Vertex or parietals with few setae, most of which located at about end of branches of epicranial sutures.

Antennae four-segmented, arising from ring-like antennal sclerite. First two segments longest, about three times as long as broad; first segment averaging 1.6 mm. in length; second, 1.8 mm.; third segment slightly shorter and smaller than the other segments with a slanting prolongation at tip, measures 1.6 mm. long; fourth or last segment about half length of either of first two segments, about 1.0 mm. long, abruptly tapering toward tip; last segment with three sensory pits, biggest one on one side and other two on opposite side, tip of this segment with sensory outgrowths. Clypeus measuring about 2.1 mm. long and 4.7 mm. wide. Post-clypeus about twice as wide as preclypeus. Labrum about 2.5 mm. long and 3.9 mm. wide, more or less hemispherical in outline, with rugged surface. Along periphery are numerous strong setae.

Lepidiota blanchardi. (Pl. 3, fig. 2). Anterior aspect of head very similar to that of *Leucopholis irrorata.* Head measuring about 6.2 mm. from back of head to fronto-clypeal suture, and 9.5 mm. in width. Clypeus about 2.3 mm. long, 5.3 mm. wide. Difference only in labrum; labrum measuring 3.1 mm. long and 4.3 mm. wide. Labrum more or less rounded at distal end, making it appear more or less semi-circular in outline. Length of antennal segments: I, 1.7 mm.; II, 2.1 mm.; III, 2.1 mm.; IV, 1.0 mm.

Mouth parts: The epipharynx. Leucopholis irrorata. (Pl. 1, fig. 6 and 7). Asymmetrical and composed of numerous setae. Distal margin thickened and covered with numerous long slender setae. Along each side are more or less uniform stout setae bent toward distal end of epipharynx. At about base of each of these setae is a short carina running toward meson. At distal region is a raised area bearing two kinds of setae. First group of setae nearest distal end, arranged in semi-circle are stout strong setae. Behind this group of setae is the distal sensory area with seventeen sense cones. Next to these setae toward meson are seventeen longer setae bent toward meson. The center of the epipharynx is smooth and devoid of setae. Radiating toward meson are slender setae. Right torma more or less straight, unbranched, and extending toward meson. Left torma short with mesal end bifurcate, one branch extending to the region of clypeus containing two groups of fine setae, the proximal sensory area.

Lepidiota blanchardi. (Pl. 3, fig. 6 and 8). Epipharynx practically of same pattern as that of *Leucopholis irrorata,* differing from latter in having only five, instead of seventeen or eighteen stout short setae between strong highly chitinized setae and distal margin of epipharynx.

Mandibles. Leucopholis irrorata. (Pl. 1, fig. 8 to 13). Mandibles unequal, strongly curved toward each other, meeting when closed at their distal ends. Color, black at distal end and tan at proximal portion. Left mandible larger than right mandible when seen at anterior aspect. Each with a grinding area or molar area at proximal portion inside curvature. Grinding area of left mandible concave, with irregular surface fitting into the more or less rounded surface with transverse grinding ridges of molar of right mandible. Right acia small, rounded, and best seen from cephalic aspect of grinding area. Left acia larger, with elongated or raised portion covering setae on cephalic aspect of mandible. Distal end of chitinized ridge above notch or cutting edge is raised or elevated. Elevation gradually decreasing towards proximal end of mandible (Dots on figures denote chitinization). At proximal region along outer margin are setae.

No stridulating apparatus present on caudal aspect. Acia visible at this aspect. At basal area of molar in the proximal area of each mandible is a bulb-like structure resting on hypopharynx when mandibles are closed. Projecting from basal attachment of mandibles are two chitinous white structures for muscle attachment. At region near molar is the rectotendon (mesal tendon). The farther tendon, the extensotendon, is very much smaller, narrow, and flattened.

Lepidiota blanchardi. (Pl. 3, fig. 9 to 14). Mandibles much stouter than those of *Leucopholis.* Abruptly tapering toward cutting edge. In other parts including chitinization essentially the same as that of *Leucopholis,* except for presence of stridulating area in this species. Stridulating area more or less oval in outline, located at caudal aspect of mandibles. This area is transversely striated or ridged. Ridges tapering toward meson.

Maxillae. Leucopholis irrorata. (Pl. 2, fig. 14 to 18). Cardo much reduced. Caudal aspect of stipes more or less trapezoidal, cephalic aspect, ellipsoidal. First segment of maxillary palpus stout and about half length of second; second and third equal in length; fourth, twice as long as third. Mala with numerous setae. At distal portion of mala are strong stout setae or spines. On cephalic aspect of maxilla running proximodistally on stipes is a line of seventeen teeth-like structures bending towards distal end of maxillae, the maxillary scraper. These structures according to Schiödte, cited by Hayes (1927), "differ in number and form according to the genera, and further noting that they vary in number from five to twenty, sometimes being straight but more often they are extremely sharp and curved."

Lepidiota blanchardi. (Pl. 3, fig. 15 to 19). Maxillae essentially similar to those of *Leucopholis*, differing only in maxillary scraper. Teeth-like structures comprising this apparatus are only nine to each maxilla and are set far apart and bent towards inner side of maxilla. Maxillary scraper rubbing against stridulating area of mandible.

Labium. Leucopholis irrorata. (Pl. 2, fig. 19). Labium reduced and hardly conspicuous. Submentum more or less rectangular. Palpi much reduced, each only two-segmented.

Lepidiota blanchardi. (Pl. 3, fig. 20). Labium of same pattern as that of *Leucopholis* without any appreciable difference.

Thorax and legs

Leucopholis irrorata. (Pl. 2, fig. 22 to 29). Thorax of third instar measuring 38.8 mm. long and 11.5 mm. wide. Prothorax divided faintly into two annulets; posterior annulet narrower than anterior one. Anterior portion of prothorax folds in, thereby covering posterior portion of head. At either side of prothorax is a chitinized plate. Back of each plate at caudal region of pleuron of prothorax is the thoracic spiracle which is more or less oval and open at caudal region. Outermost portion of a spiracle, the peritreme, is dark tan, nearly enclosing the light and more or less oval bulla. Peritreme in all spiracles narrow where they open. Prothoracic spiracles differ from other spiracles in that they are much bigger, about twice the size of other spiracles. Also, prothoracic spiracles open at caudal region, while abdominal spiracles are small and open at anterior portion. Prothoracic legs shortest; average length of coxa, 3.1 mm.; femur, 2.3 mm.; tibia, 2.0 mm. Mesothorax divided into three well-defined annulets. Central annulet biggest, other annulets small and do not extend plainly to sides. Devoid of spiracles. Legs bigger than prothoracic legs; average length of coxa, 4.4 mm.; femur, 2.5 mm.; tibia, 2.0 mm. Metathorax divided into three annulets with central annulet biggest. Average length of coxa, 5.2 mm.; femur, 2.7 mm.; tibia, 1.8 mm. Length of claws of legs: fore leg, 1.0 mm.; middle leg, 1.0 mm.; hind leg, 0.4 mm. Apparently difference of legs lies in relative length of coxa, though there is a faint or slightly visible increase in size of other parts from prothoracic legs to metathoracic legs. Coxa of prothoracic legs about two-thirds, length of coxa of metathoracic legs. Coxa of metathoracic legs midway between length of coxae of prothoracic and metathoracic legs. Ratio of length of coxae of first to third legs about 1 : 1.5 : 1.8. Ratio of length of claws about 3 : 3 : 1.

Legs provided with numerous setae, particularly tibia and femur. Strong stout setae on distal region of tibia around base of tarsal claw. Coxa cylindrical, delimited at distal end by elongated narrow chitinization, making oblique cut at end to where it joins the trochanter; trochanter more or less trapezoidal in lateral outline, but assuming a more or less cylindrical form like coxa; femur clavate, more or less hemispherical in outline at lateral aspect; tibia more or less ovoid, bearing at distal portion a claw (tarsal claw); tarsus absent. Tarsal claw provided at base with a pair of setae set at opposite sides. Tarsal claws of prothoracic and mesothoracic legs long, prominent; that of metathoracic leg blunt, reduced and hardly visible.

Lepidiota blanchardi. (Pl. 4, fig. 23 to 30). Thorax of third instar larva measures 39.6 mm. long and 11.9 mm. wide. No apparent difference from that of *Leucopholis irrorata;* legs and spiracles similar, except in size. Length of segments of legs: fore legs, coxa 3.6 mm.; femur 2.9 mm.; tibia 2.3 mm.; middle leg, coxa 5.3 mm.; femur 3.3 mm.; tibia 2.4 mm.; hind leg, coxa 6.1 mm.; femur 3.4 mm.; tibia 2.3 mm. Length of claws: fore leg, 1.2 mm.; middle leg, 1.2 mm.; hind leg, 0.4 mm. Ratio of length of coxae from first to third leg about 1 : 1.5 : 2. Ratio of length of claw, 3 : 3 : 1.

Abdomen

Leucopholis irrorata. (Pl. 2, fig. 30 and 31). Abdomen more or less cylindrical, divided into ten segments, devoid of appendages. Each of first eight segments bears a pair of spiracles, one on each side. Abdominal spiracles opening anteriorly. Width of opening of peritreme of right spiracles: first, 0.1 mm.; second, 0.2 mm.; third, 0.1 mm.; fourth, 0.1 mm.; fifth, 0.1 mm.; sixth, 0.06 mm.; seventh, 0.06 mm.; eighth, 0.07 mm.; ninth, 0.1 mm. First abdominal segment with two annulets. Second to sixth segments each divided into three annulets; seventh segment with two annulets while last three not divided. Tenth abdominal segment largest of abdominal segments and bearing numerous setae at distal region where transverse anal slit is found. Pleura not differentiated from terga in all abdominal segments. On dorsal region of first six segments, extending to pleura just above spiracles, are numerous thickly set, small, short, more or less uniform setae, with very few longer setae interspersed. At the sterna and part of pleura of first nine abdominal segments are scattered long setae.

Lepidiota blanchardi. (Pl. 4, fig. 31 and 32). Abdomen very similar to that of *Leucopholis*, but tapering markedly toward attachment to thorax with a marked enlargement toward posterior portion of abdomen. The greatest difference is in the radula. Anal slit angular. Width of opening of peritreme of right spiracles: first, 0.1 mm.; second, 0.2 mm.; third, 0.1 mm.; fourth, 0.1 mm.; fifth, 0.1 mm.; sixth, 0.1 mm.; seventh, 0.1 mm.; eighth, 0.1 mm.; ninth, 0.14 mm.

Radula. Leucopholis irrorata. (Pl. 2, fig. 31). Distal portion of last abdominal segment provided with numerous setae. Setae at lateral regions long, slender, and numerous. At center of radula are two rows of prominent long setae bent toward meson with their tips overlapping those of the opposite setae. In some specimens the tips of the setae even extend beyond basal attachment of the setae in the opposite row. Number of setae to each row variable. The minimum found to each row was 14; maximum, 21; and mean, 19.03. Setae not in straight rows. According to Hayes (1927), "in a study of digging habits of white grubs in observation cages the writer has frequently noticed the grubs making use of this structure to rake off the mouth parts which often become covered with soil as the larva burrows through the soil, especially if it is very wet and sticky. Since the general term 'ventral aspect of the last abdominal segment' is cumbersome it is preferable to speak of it as the rake or radula." Hayes further states that in *Anomala kansana* H. and McC., the radula does not differ strikingly in the second or third instar. Surrounding the double rows of central recumbent setae are larger setae more or less evenly distributed but not arranged in rows. These setae are bent or hooked at their ends. In *Leucopholis*, average length of setae composing rows 0.38 mm.; average width, 0.04 mm. Average length of setae occupying rest of radula 0.46 mm.; average width, 0.07 mm.

Lepidiota blanchardi. (Pl. 4, fig. 32). The radula differs from that of *Leucopholis irrorata* in the double rows of central setae. Setae composing these two rows in *Lepidiota* are short, stout, bent towards meson but hardly touching tips of opposite setae. Also, rows of setae in *Lepidiota* about twice length those in *Leucopholis*. Number of setae to the rows also variable ranging from fourteen to thirty-one with an average of about twenty-one (20.94). Setae arranged in rows. Average length of setae composing rows about 0.26 mm.; average width, about 0.07 mm. Average length of setae occupying rest of radula about 0.57 mm.; average width, about 0.06 mm.

DIAGNOSTIC CHARACTERS OF LARVAE OF THE DIFFERENT FORMS STUDIED

Description of third instar larvae

All the species of grubs studied have several characters in common. Color of body is creamy white; head, tan or brown. Body doubled up so that radula nearly touches head; divided into three-segmented thorax and ten-segmented abdomen; each segment except the last three abdominal segments divided into annulets. Antenna four-segmented. Each thoracic segment bears a pair of legs. First or fore pair of legs shortest; third or hind pair longest. On both pleura of first thoracic segment is a chitinized plate and on caudolateral area is the thoracic spiracle. Thoracic spiracle about twice as large as other spiracles; open at caudal portion. Each of first eight abdominal segments bears a pair of spiracles at pleura; spiracles open anteriorly. Last or tenth abdominal segment largest. Lacinia and galea fused, forming mala; maxillary palpus four-segmented.

Anomala humeralis. (Pl. 8). Head measures 2.10 mm. from back of head to fronto-clypeal suture; 3.10 mm. wide. Head small in proportion to body. Lengths of antennal segments: first, 0.45 mm.; second, 0.65 mm.; third, 0.36 mm.; fourth, 0.45 mm. Maxillary scraper composed of 6.57 closely bent, sharp-pointed teeth arranged in a row; teeth bending along the row towards distal end of maxilla. Epipharynx asymmetrical, distal margin lobed, with long stout articulate setae. Along rounded lateral margin are short uniform curved setae. At bases of those setae are the lateral striae running toward meson; striae gradually shortening toward distal and proximal portion of epipharynx. Tormae short and not uniform; left torma double-curved; right torma narrow, more or less straight, extending toward meson. Distal sensory area with three prominent stout spines and sense cones. Body about 19.8 mm. long, 4.9 mm. wide at thorax. Body sparsely covered with setae, thickest at tergum extending to pleuron of second to seventh abdominal segments. First leg smallest, gradually increasing in size to third or last leg. First leg: coxa, 0.8 mm. long; femur, 0.7 mm. long; tibia, 0.6 mm. long. Second leg: coxa, 1.3 mm.; femur, 0.9 mm.; tibia, 0.7 mm. Third leg: coxa, 1.9 mm.; femur, 0.9 mm.; tibia, 0.7 mm. long. Ratio of length of coxae from first to third leg about 1 : 1.6 : 2. Length of claws: fore leg, 0.4 mm.; middle leg, 0.4 mm.; hind leg, 0.3 mm. Ratio of length of claws from fore leg to hind leg about 1.5 : 1.5 : 1. Opening of thoracic spiracle about 0.05 mm. Abdomen enlarged at region of eighth and ninth segments. Anal segment covered with thick setae at dorsal area. Anal slit transverse. Radula with a double row of slender setae gradually increasing in size towards posterior ends of rows; about 9 to 10 (average 9.14) setae to a row, bent toward meson, rows diverging toward caudal ends. Length of setae in the rows varies, the setae in the part where rows are close shorter than setae nearest anal slit; average length of setae composing rows, 0.18 mm.; average width of setae at the base, 0.02 mm. Rest of radula occupied by short stout setae with an average length of 0.17 mm. and average width of 0.03 mm.

Stephanopholis philippinensis.[2] (Pl. 5). (Second instar larva). Head measures 3.5 mm. from back of head to fronto-clypeal suture; 4.7 mm. wide. Head proportionate to body. Length of antennal segments: first, 0.8 mm.; second, 1.0 mm.; third, 0.8 mm.; fourth, 0.6 mm. Maxillary scraper composed of about fifteen closely set teeth with rounded tips slightly bending toward distal portion of maxilla. Epipharynx more or less rounded. Distal portion with stout short setae of about same size as setae along lateral margins. Lateral striae prominent. Left torma occupying large irregular area. Distal sensory area with about thirteen stout spines.

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[2] One grub from Occidental Negros, loaned by the late Mr. Alonzo W. Lopez, formerly entomologist of the Philippine Sugar Association.

Setae on epipharynx numerous, short, stout. Body about 20.5 mm. long and 7.6 mm. wide at thorax; covered with setae at tergum extending to sides of first to seventh abdominal segments, very thickly set. First leg smallest, third longest. First leg; coxa, 1.4 mm. long; femur, 1.4 mm. long; tibia, 1.2 mm. long. Second leg: coxa, 2.0 mm.; femur, 1.5 mm.; tibia, 1.2 mm. Third leg: coxa, 2.6 mm.; femur, 1.6 mm.; tibia, 1.1 mm. Ratio of length of coxae of first to third leg about 1 : 1.4 : 2. Length of claws: fore leg, 0.4 mm.; middle leg, 0.4 mm.; hind leg, 0.2 mm. Ratio of length of claws from fore leg to hind leg about 2 : 1.8 : 1. Setae at tip of tibia around claw very much reduced, stout. Thoracic spiracles about twice any of abdominal spiracles in size; opening of peritreme 0.06 mm., about twice that of thoracic spiracle of *Lepidiota blanchardi*. Abdomen enlarged at ninth and tenth abdominal segments. Setae on thorax and on eighth to ninth abdominal segments sparse. Most distal region of anal segment around anal slit small, much reduced. Anal slit angular. Radula with two prominent longitudinal long rows of short, stout setae about twenty to a row; rows close and not straight, located at center of radula. Setae on rows have an average length of 0.12 mm. and an average width at base of 0.03 mm. Rest of radula is occupied by setae with an average length of 0.20 mm. and an average width of 0.05 mm.

Adoretus luridus. (Pl. 9). Head about 2.0 mm. from back of head to fronto-clypeal suture; 3.1 mm. wide. Length of antennal segments: first, 0.4 mm.; second, 0.7 mm.; third, 0.4 mm.; fourth, 0.4 mm. Maxillary scraper made up of a row of about nine (average 9.06) sharp pointed, closely bent teeth. Epipharynx nearly symmetrical, lobed at distal portion in which long articulate setae are located. Tormae uneven, left torma curved toward meson of epipharynx; right torma narrow and straight. Distal sensory area with sense cones. Lateral striae very prominent. Body about 18.3 mm. long; 4.5 mm. wide at thorax; covered with setae, thickest at tergum extending to pleuron of first to seventh abdominal segments. First leg shortest, third leg longest. First leg: coxa, 0.7 mm.; femur, 0.6 mm.; tibia, 0.7 mm. Second leg: coxa, 1.3 mm.; femur, 0.9 mm.; tibia, 0.7 mm. Third leg: coxa, 1.8 mm.; femur, 1.0 mm.; tibia, 0.8 mm. Ratio of length of coxae from first to third leg about 1 : 2 : 2.6. First leg very short, third leg longest. Claws of legs subequal in length; fore leg 0.4 mm., middle leg 0.4 mm., hind leg 0.4 mm. Opening of peritreme of thoracic spiracles 0.1 mm., about twice that of *Adoretus ranunculus.* Setae on thorax and eighth to ninth abdominal segments sparse. Abdomen enlarged at eighth and ninth segments; tenth segment abruptly tapering posteriorly. Most distal area of last abdominal segment densely covered with setae. Anal slit transverse. Radula without a double row of prominent setae. Setae composing radula more or less uniform, hooked, evenly set, numbering about 75 (average 74.63). Average length of uniform setae about 0.15 mm.; average width at base about 0.03 mm.

Adoretus ranunculus. (Pl. 10). Head, about 2.1 mm. from back of head to fronto-clypeal suture; 3.0 mm. wide. Length of antennal segments: first, 0.4 mm.; second, 0.6 mm.; third, 0.3 mm.; fourth, 0.4 mm. Maxillary scraper very similar to that of *A. luridus* Blanchard (9 teeth). Epipharynx nearly symmetrical, faintly lobed at distal portion, covered with long articulate setae. Left torma narrow, curved, enlarged at base of labrum, and extending far into meson. Distal sensory area with six closely set stout spines and numerous sense cones. Lateral striae very short, almost inconspicuous. Body about 17.2 mm. long, 4.4 mm. wide at thorax; covered with setae, thickest at tergum extending to pleuron of first to sixth abdominal segments. First leg: coxa, 0.6 mm. long; femur, 0.6 mm. long; tibia, 0.6 mm. long. Second leg: coxa, 0.9 mm.; femur, 0.7 mm.; tibia, 0.7 mm. Third leg: coxa, 1.3 mm.; femur, 0.8 mm.; tibia, 0.7 mm. Ratio of length of coxae from first to third leg about 1 : 1.5 : 2 or 2 : 3 : 4. Claws of legs subequal in length; fore leg 0.33 mm., middle leg 0.39 mm., hind leg 0.38 mm. Opening of peritreme of thoracic spiracles 0.04 mm., about half that of *A. luridus* Blanchard. Abdomen enlarged at eighth and ninth segments. Most distal portion of abdomen covered with setae. Anal slit, transverse. Radula very similar to that of *A. luridus* Blanchard, except that the number of setae composing it is smaller, about 50 (average 49.86). Average length of setae, 0.13 mm.; average width at base about 0.03 mm.

Autoserica nigrorubra. (Pl. 7). Head about 2.1 mm. from back of head to fronto-clypeal suture; about 3.1 mm. wide. Length of antennal segments: first, 0.4 mm.; second, 0.8 mm.; third, 0.4 mm.; fourth, 0.3 mm. Maxillary scraper composed of about twenty-three closely set teeth with rounded tips. Stipes of maxilla exceptionally big, very conspicuous, creamy white, occupying a distinct position under head. Epipharynx more or less symmetrical. Distal margin prominently lobed. At lateral margins are uniform short setae at bases of which arise the lateral striae; these rows of setae extend far into the epipharynx at their distal portions, almost meeting between the distal sensory area and the distal portion of the lobe. Setae composing portion of rows of marginal setae extending into the epipharynx long and articulate. At distal portion of lobe are two prominent stout non-articulate setae. Distal sensory area composed of three stout setae. Tormae reduced. Body about 17.63 mm. long, 4.78 mm. wide at thorax; covered with setae, thickest at tergum extending to pleuron of first to seventh abdominal segments. First leg shortest, third leg longest. First leg: coxa, 0.9 mm. long; femur, 0.7 mm. long; tibia, 0.7 mm long. Second leg: coxa, 1.3 mm.; femur, 0.8 mm.; tibia, 0.8 mm. Third leg: coxa, 1.6 mm.; femur, 0.9 mm.; tibia, 0.7 mm. Ratio of length of coxae from first to third leg about 1 : 1.4 : 1.7. Claws of first and second legs about same length, third claw about two-fifths of length of either first or second claw. Length of claws: fore leg 0.4 mm., middle leg 0.4 mm., hind leg 0.2 mm. Opening of peritreme of thoracic spiracles very wide, 0.15 mm.; occupying about two-fifths of peritreme. Abdomen slightly tapering from ninth segment to tip of abdomen. Anal slit longitudinal. Radula with a row of about twenty (average 20.36) prominent closely set setae arranged in semi-circle toward ventral end of anal slit; average length of component setae 0.17 mm.; average width at base 0.02 mm. Remainder of radula composed of numerous more or less uniform setae, about sixty-seven (average 67.18); average length about 0.08 mm., average width about 0.02 mm.

Holotrichia flachi. (Pl. 6). Head about 3.7 mm. from back of head to fronto-clypeal suture; about 5.4 mm. wide. Length of antennal segments: first, 1.0 mm.; second, 1.4 mm.; third, 1.0 mm.; fourth, 0.7 mm. Maxillary scraper composed of about fourteen closely set teeth with blunt ends, making the teeth appear rectangular at lateral aspect. Epipharynx asymmetrical, lobed at distal portion and covered with long articulate setae. Lateral striae prominent. Distal sensory area with numerous stout spines. Left torma wide and curved; right torma narrow, more or less straight. Proximal sensory area with two prominent chitinized areas, the chitinous plate and sense cone. Remainder of epipharynx with short setae bent toward meson. Body about 33.9 mm. long, 8.8 mm. wide at thorax. Setae sparsely distributed throughout body. Thickest setae found at tergum extending to pleuron of first six abdominal segments. First leg: coxa, 1.8 mm. long; femur, 1.7 mm. long; tibia, 1.5 mm. long. Second leg: coxa, 2.5 mm.; femur, 1.7 mm.; tibia, 1.6

mm. Third leg: coxa, 3.2 mm.; femur, 1.8 mm.; tibia, 1.5 mm. Ratio of length of coxae from first to third leg about 1 : 1.4 : 1.8. Claws of first and second legs of same length, third claw about two-fifths length of either first or second leg. Length of claws: fore leg 0.6 mm., middle leg 0.6 mm., hind leg 0.3 mm. Opening of peritreme of thoracic spiracle 0.01 mm., very narrow, peritreme almost meeting. Distal half of abdomen enlarged, except last segment which tapers abruptly toward anal slit. Anal slit angulate. Radula with two long, prominent rows of setae, about twenty-four (average 24.5) to a row; setae with rounded tips, more or less uniform in size and closely set, bent toward meson; rows slightly curving outward and far apart. Average length of setae composing rows, 0.14 mm., average width at base about 0.04 mm. Remainder of radula occupied by strong well distributed setae; average length about 0.26 mm., average width about 0.04 mm.

LARVAL KEY TO THE SPECIES

1. Anal slit angular, with two prominent longitudinal rows of setae at center of radula; setae bent toward meson .... (2)

   Anal slit not angular; with or without two prominent rows of setae on radula .... (3)

2. Prominent longitudinal rows of setae long, composed of short, stout setae, about twenty-one to a row; rows close and not straight; setae on one side touching opposite setae. First six abdominal segments covered at tergum and extending to pleuron with thick short setae .... (4)

   Setae composing rows not as above .... (5)

3. Anal slit longitudinal, with a row of about twenty prominent, closely set setae at radula, which are arranged in semicircle toward ventral end of anal slit. Radula composed of numerous (about sixty-seven) short setae; opening of peritreme of thoracic spiracle very wide; maxillary scraper composed of about twenty-three closely set teeth with rounded tips .... *Autoserica nigrorubra* Brenske

   Anal slit transverse .... (6)

4. Maxillary scraper composed of about nine conical teeth set far apart in a row, size of teeth gradually increasing toward distal end of row; opening of peritreme of thoracic spiracle narrow .... *Lepidiota blanchardi* Dalla Torre

   Maxillary scraper composed of about fifteen closely set, round-tipped teeth slightly bending toward distal portion of maxilla; opening of thoracic spiracles about half that of foregoing species .... *Stephanopholis philippinensis* Brenske

5. Setae composing the two long prominent rows, about twenty-four or twenty-five to a row, rounded tips, more or less uniform and closely set, bent toward meson; rows slightly curving outward, far apart. Maxillary scraper composed of about fourteen closely set teeth with blunt tips .... *Holotrichia flachi* Brenske

   Setae composing two prominent rows about nineteen to a row; long, slender, closely set, bent toward meson, their tips extending to as far as bases of opposite setae. Rows short, about half length of rows in *Lepidiota blanchardi* and not straight. Maxillary scraper composed of about seventeen recumbent teeth. Opening of peritreme of thoracic spiracles narrow .. *Leucopholis irrorata* Chevrolat

6. Radula with two rows of setae. Setae composing the two rows about nine to ten to each row; slender, gradually increasing in size posteriorly, bent toward meson; rows diverging toward caudal ends. Maxillary scraper composed of about seven closely bent sharp-pointed setae .... *Anomala humeralis* Burmeister

   Setae on radula evenly distributed without any prominent rows of setae .... (7)

7. Setae on radula rather long, more or less uniform, about fifty in number. Opening of peritreme of thoracic spiracles about half that of *Adoretus luridus* .... *Adoretus ranunculus* Burmeister

   Setae on radula about one and a half times as many as those of *A. ranunculus* Burm. (Seventy-five); opening of peritreme of thoracic spiracles larger than that of preceding species ...... *Adoretus luridus* Blanchard

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TABLE 1

Measurements of head and body

	NUMBER OF INDIVIDUALS	HEAD					
		Length	Standard deviation	Coefficient of variation	Width	Standard deviation	Coefficient of variation
		mm.	*mm.*	*per cent*	*mm.*	*mm.*	*per cent*
Leucopholis irrorata							
Maximum		5.5			8.5		
Minimum		4.6			7.2		
Average	32	5.256 ± 0.030	0.246 ± 0.021	4.683 ± 0.395	8.038 ± 0.043	0.352 ± 0.030	4.374 ± 0.369
Lepidiota blanchardi							
Maximum		7.0			10.5		
Minimum		5.5			8.9		
Average	79	6.243 ± 0.030	0.390 ± 0.021	6.247 ± 0.335	9.495 ± 0.027	0.358 ± 0.019	3.772 ± 0.202
Stephanopholis philippinensis							
Maximum							
Minimum							
Average	1	3.5			4.7		
Holotrichia flachi							
Maximum		4.0			5.6		
Minimum		3.5			5.0		
Average	6	3.650 ± 0.057	0.189 ± 0.037	5.186 ± 1.010	5.367 ± 0.062	0.206 ± 0.040	3.8398 ± 0.748
Anomala humeralis							
Maximum		2.2			3.2		
Minimum		2.0			3.0		
Average	7	2.1 ± 0.025	0.093 ± 0.017	0.795 ± 0.143	3.1 ± 0.025	0.093 ± 0.017	3.203 ± 0.461
Autoserica nigrorubra							
Maximum		2.2			3.2		
Minimum		2.0			3.0		
Average	11	2.064 ± 0.016	0.077 ± 0.011	3.737 ± 0.537	3.109 ± 0.021	0.100 ± 0.014	0.538 ± 0.097
Adoretus luridus							
Maximum		2.2			3.2		
Minimum		2.0			3.0		
Average	16	2.03 ± 0.012	0.068 ± 0.001	0.059 ± 0.007	3.05 ± 0.015	0.087 ± 0.015	0.502 ± 0.060
Adoretus ranunculus							
Maximum		2.20					
Minimum		2.00					
Average	7	2.09 ± 0.027	0.099 ± 0.026	4.350 ± 0.784	3.00		

TABLE 1 (continued)

	NUMBER OF INDIVIDUALS	BODY					
		Length	Standard deviation	Coefficient of variation	Width	Standard deviation	Coefficient of variation
		mm.	*mm.*	*per cent*	*mm.*	*mm.*	*per cent*
Leucopholis irrorata							
Maximum		46.5			13.0		
Minimum		31.0			9.5		
Average	32	38.844 ± 0.419	3.458 ± 0.292	8.903 ± 0.751	11.534 ± 0.105	0.870 ± 0.073	7.541 ± 0.363
Lepidiota blanchardi							
Maximum		51.0			15.0		
Minimum		33.5			9.2		
Average	79	39.634 ± 0.272	3.567 ± 0.191	8.999 ± 0.483	11.928 ± 0.092	1.207 ± 0.065	10.116 ± 0.543
Stephanopholis philippinensis							
Maximum							
Minimum							
Average	1	20.5			7.6		
Holotrichia flachi							
Maximum		35.5			9.0		
Minimum		32.5			8.5		
Average	6	33.917 ± 0.374	1.239 ± 0.241	3.653 ± 0.711	8.817 ± 0.061	0.203 ± 0.040	2.307 ± 0.449
Anomala humeralis							
Maximum		21.6			5.1		
Minimum		19.0			4.6		
Average	7	19.757 ± 0.222	0.807 ± 0.145	0.736 ± 0.133	4.871 ± 0.052	0.191 ± 0.034	3.913 ± 0.705
Autoserica nigrorubra							
Maximum		18.0			5.0		
Minimum		17.2			4.5		
Average	11	17.627 ± 0.060	0.283 ± 0.041	1.606 ± 0.231	4.782 ± 0.035	0.164 ± 0.021	3.432 ± 0.494
Adoretus luridus							
Maximum		19.5			4.8		
Minimum		17.4			4.0		
Average	16	18.33 ± 0.098	0.562 ± 0.099	0.542 ± 0.065	4.47 ± 0.040	0.231 ± 0.041	0.914 ± 0.109
Adoretus ranunculus							
Maximum		18.0			4.80		
Minimum		16.2			4.20		
Average	7	17.17 ± 0.183	0.210 ± 0.056	1.224 ± 0.221	4.43 ± 0.062	0.225 ± 0.060	1.310 ± 0.236

TABLE 2

Measurements of clypeus and labrum

	NUMBER OF INDIVIDUALS	CLYPEUS					
		Length	Standard deviation	Coefficient of variation	Width	Standard deviation	Coefficient of variation
		mm.	*mm.*	*per cent*	*mm.*	*mm.*	*per cent*
Leucopholis irrorata							
Maximum		2.5			5.0		
Minimum		1.9			4.0		
Average	32	2.084 ± 0.022	0.184 ± 0.016	8.824 ± 0.744	4.653 ± 0.035	0.289 ± 0.024	6.219 ± 0.524
Lepidiota blanchardi							
Maximum		2.5			6.0		
Minimum		2.0			4.8		
Average	79	2.337 ± 0.017	0.223 ± 0.012	9.536 ± 0.512	5.295 ± 0.025	0.334 ± 0.018	6.303 ± 0.338
Stephanopholis philippinensis							
Maximum							
Minimum							
Average	1	0.916			2.577		
Holotrichia flachi							
Maximum		1.32			3.52		
Minimum		1.08			3.04		
Average	6	1.16 ± 0.024	0.080 ± 0.016	6.897 ± 1.343	3.23 ± 0.144	0.151 ± 0.029	4.672 ± 0.910
Anomala humeralis							
Maximum		0.611			1.565		
Minimum		0.573			1.451		
Average	7	0.578 ± 0.004	0.013 ± 0.002	2.311 ± 0.417	1.500 ± 0.009	0.034 ± 0.006	2.241 ± 0.404
Autoserica nigrorubra							
Maximum		0.573			1.527		
Minimum		0.515			1.470		
Average	11	0.557 ± 0.005	0.021 ± 0.003	3.816 ± 0.549	1.503 ± 0.005	0.024 ± 0.003	1.541 ± 0.222
Adoretus luridus							
Maximum		0.630			1.527		
Minimum		0.573			1.336		
Average	16	0.588 ± 0.004	0.020 ± 0.002	3.484 ± 0.415	1.442 ± 0.008	0.046 ± 0.006	3.207 ± 0.382
Adoretus ranunculus							
Maximum		0.573			1.527		
Minimum		0.515			1.432		
Average	7	0.543 ± 0.007	0.024 ± 0.004	4.458 ± 0.804	1.481 ± 0.008	0.029 ± 0.005	1.932 ± 0.348

TABLE 2 (continued)

	NUMBER OF INDIVIDUALS	LABRUM					
		Length	Standard deviation	Coefficient of variation	Width	Standard deviation	Coefficient of variation
		mm.	*mm.*	*per cent*	*mm.*	*mm.*	*per cent*
Leucopholis irrorata							
Maximum		3.0			4.2		
Minimum		2.0			3.5		
Average	32	2.519 ± 0.025	0.204 ± 0.017	8.089 ± 0.682	3.928 ± 0.021	0.172 ± 0.014	4.374 ± 0.369
Lepidiota blanchardi							
Maximum		3.5			5.0		
Minimum		2.8			4.0		
Average	79	3.111 ± 0.016	0.204 ± 0.011	6.550 ± 0.351	4.341 ± 0.020	0.266 ± 0.014	6.139 ± 0.329
Stephanopholis philippinensis							
Maximum							
Minimum							
Average	1	1.527			2.138		
Holotrichia flachi							
Maximum		1.76			3.52		
Minimum		1.60			2.60		
Average	6	1.67 ± 0.017	0.055 ± 0.011	3.298 ± 0.642	2.98 ± 0.130	0.433 ± 0.084	14.515 ± 2.826
Anomala humeralis							
Maximum		0.859			1.336		
Minimum		0.725			1.241		
Average	7	0.777 ± 0.012	0.044 ± 0.008	5.680 ± 1.024	1.282 ± 0.011	0.039 ± 0.007	3.024 ± 0.545
Autoserica nigrorubra							
Maximum		0.764			1.241		
Minimum		0.649			1.145		
Average	11	0.722 ± 0.009	0.044 ± 0.006	6.052 ± 0.870	1.192 ± 0.008	0.037 ± 0.005	3.081 ± 0.443
Adoretus luridus							
Maximum		0.764			1.336		
Minimum		0.649			1.241		
Average	16	0.716 ± 0.006	0.047 ± 0.006	6.533 ± 0.779	1.289 ± 0.007	0.042 ± 0.005	3.271 ± 0.390
Adoretus ranunculus							
Maximum		0.802			1.260		
Minimum		0.706			1.222		
Average	7	0.761 ± 0.009	0.033 ± 0.006	4.379 ± 0.789	1.233 ± 0.003	0.014 ± 0.003	1.128 ± 0.203

TABLE 3

Measurements of antennal segments

	NUMBER OF INDIVIDUALS	LENGTH OF ANTENNAL SEGMENTS					
		First	Standard deviation	Coefficient of variation	Second	Standard deviation	Coefficient of variation
Leucopholis irrorata		*mm.*	*mm.*	*per cent*	*mm.*	*mm.*	*per cent*
Maximum		1.68			2.04		
Minimum		1.50			1.60		
Average	32	1.64 ± 0.002	0.059 ± 0.005	3.596 ± 0.303	1.836 ± 0.013	0.107 ± 0.009	5.838 ± 0.492
Lepidiota blanchardi							
Maximum		2.00			2.80		
Minimum		1.60			1.90		
Average	79	1.743 ± 0.008	0.110 ± 0.006	6.285 ± 0.337	2.131 ± 0.010	0.126 ± 0.007	5.921 ± 0.318
Stephanopholis philippinensis							
Maximum							
Minimum							
Average	1	0.80			1.00		
Holotrichia flachi							
Maximum		1.216			1.72		
Minimum		0.800			1.22		
Average	6	1.013 ± 0.041	0.137 ± 0.040	13.521 ± 2.633	1.347 ± 0.052	0.172 ± 0.050	12.740 ± 2.481
Anomala humeralis							
Maximum		0.48			0.656		
Minimum		0.44			0.640		
Average	7	0.453 ± 0.004	0.014 ± 0.003	3.112 ± 0.561	0.645 ± 0.002	0.006 ± 0.001	0.015 ± 0.003
Autoserica nigrorubra							
Maximum					0.80		
Minimum					0.72		
Average	11	0.400			0.745 ± 0.006	0.026 ± 0.004	3.558 ± 0.512
Adoretus luridus							
Maximum		0.448			0.736		
Minimum		0.352			0.624		
Average	15	0.370 ± 0.004	0.024 ± 0.004	6.473 ± 0.797	0.701 ± 0.007	0.038 ± 0.007	5.460 ± 0.672
Adoretus ranunculus							
Maximum		0.416			0.64		
Minimum		0.400			0.56		
Average	7	0.408 ± 0.002	0.007 ± 0.002	1.815 ± 0.327	0.605 ± 0.006	0.023 ± 0.006	3.863 ± 0.696

TABLE 3 (continued)

	NUMBER OF INDIVIDUALS	LENGTH OF ANTENNAL SEGMENTS					
		Third	Standard deviation	Coefficient of variation	Fourth	Standard deviation	Coefficient of variation
		mm.	*mm.*	*per cent*	*mm.*	*mm.*	*per cent*
Leucopholis irrorata							
Maximum		1.74			1.04		
Minimum		1.40			0.80		
Average	32	1.570 ± 0.013	0.107 ± 0.009	6.801 ± 0.573	0.966 ± 0.006	0.053 ± 0.005	5.537 ± 0.467
Lepidiota blanchardi							
Maximum		2.30			1.20		
Minimum		1.80			0.90		
Average	79	2.078 ± 0.009	0.116 ± 0.006	5.604 ± 0.301	1.006 ± 0.005	0.060 ± 0.003	6.013 ± 0.323
Stephanopholis philippinensis							
Maximum							
Minimum							
Average	1	0.76			0.60		
Holotrichia flachi							
Maximum		1.08			0.768		
Minimum		0.896			0.624		
Average	6	0.969 ± 0.018	0.059 ± 0.017	6.131 ± 1.194	0.679 ± 0.014	0.048 ± 0.014	7.017 ± 1.366
Anomala humeralis							
Maximum		0.40			0.48		
Minimum		0.32			0.40		
Average	7	0.362 ± 0.008	0.092 ± 0.017	0.460 ± 0.083	0.447 ± 0.008	0.029 ± 0.005	6.376 ± 1.149
Autoserica nigrorubra							
Maximum		0.48			0.336		
Minimum		0.40			0.320		
Average	11	0.417 ± 0.005	0.024 ± 0.003	5.775 ± 0.830	0.328 ± 0.002	0.008 ± 0.001	2.325 ± 0.334
Adoretus luridus							
Maximum		0.400			0.400		
Minimum		0.336			0.336		
Average	15	0.390 ± 0.003	0.017 ± 0.003	4.445 ± 0.547	0.363 ± 0.003	0.015 ± 0.003	4.008 ± 0.494
Adoretus ranunculus							
Maximum		0.320			0.400		
Minimum		0.304			0.376		
Average	7	0.315 ± 0.002	0.007 ± 0.002	2.299 ± 0.414	0.392 ± 0.003	0.010 ± 0.003	2.439 ± 0.440

TABLE 4

Number of teeth in maxillary scraper

	NUMBER OF INDIVIDUALS	NUMBER OF TEETH	STANDARD DEVIATION	COEFFICIENT OF VARIATION
				per cent
Leucopholis irrorata				
Maximum		20		
Minimum		13		
Average	31	16.774 ± 0.288	2.338 ± 0.200	13.937 ± 1.194
Lepidiota blanchardi				
Maximum		11		
Minimum		7		
Average	79	9.039 ± 0.073	0.938 ± 0.051	10.378 ± 0.568
Stephanopholis philippinensis				
Maximum				
Minimum				
Average	1	15		
Holotrichia flachi				
Maximum		16		
Minimum		12		
Average	6	14 ± 0.389	1.291 ± 0.251	9.222 ± 1.796
Anomala humeralis				
Maximum		8		
Minimum		6		
Average	7	6.571 ± 0.201	0.728 ± 0.131	11.085 ± 1.998
Autoserica nigrorubra				
Maximum		25		
Minimum		21		
Average	11	23 ± 0.315	1.477 ± 0.212	6.422 ± 0.924
Adoretus luridus				
Maximum		10		
Minimum		8		
Average	16	9.063 ± 0.020	0.747 ± 0.089	8.247 ± 0.983
Adoretus ranunculus				
Maximum		10		
Minimum		7		
Average	7	9 ± 0.636	1.069 ± 0.193	11.879 ± 2.141

TABLE 5

Measurements of spiracles

	NUMBER OF INDIVIDUALS	WIDTH OF OPENING OF FIRST RIGHT SPIRACLE	STANDARD DEVIATION	COEFFICIENT OF VARIATION
		mm.	*mm.*	*per cent*
Leucopholis irrorata				
Maximum		0.253		
Minimum		0.034		
Average	32	0.124 ± 0.006	0.052 ± 0.004	41.708 ± 3.517
Lepidiota blanchardi				
Maximum		0.270		
Minimum		0.017		
Average	79	0.098 ± 0.004	0.058 ± 0.003	59.514 ± 3.194
Stephanopholis philippinensis				
Maximum				
Minimum				
Average	1	0.056		
Holotrichia flachi				
Maximum		0.019		
Minimum		0.000		
Average	6	0.014 ± 0.001	0.003 ± 0.001	2.211 ± 0.431
Anomala humeralis				
Maximum		0.056		
Minimum		0.046		
Average	7	0.053 ± 0.001	0.003 ± 0.001	5.873 ± 1.059
Autoserica nigrorubra				
Maximum		0.167		
Minimum		0.143		
Average	11	0.154 ± 0.001	0.006 ± 0.001	4.173 ± 0.600
Adoretus luridus				
Maximum		0.149		
Minimum		0.174		
Average	16	0.104 ± 0.001	0.026 ± 0.003	24.990 ± 2.980
Adoretus ranunculus				
Maximum		0.074		
Minimum		0.022		
Average	7	0.043 ± 0.005	0.016 ± 0.003	37.955 ± 6.842

TABLE 5 (continued)

	NUMBER OF INDIVIDUALS	WIDTH OF OPENING OF SECOND SPIRACLE	STANDARD DEVIATION	COEFFICIENT OF VARIATION
		mm.	*mm.*	*per cent*
Leucopholis irrorata				
Maximum		0.236		
Minimum		0.067		
Average	32	0.187 ± 0.004	0.033 ± 0.003	17.879 ± 1.507
Lepidiota blanchardi				
Maximum		0.337		
Minimum		0.101		
Average	77	0.223 ± 0.005	0.063 ± 0.003	28.122 ± 1.529
Stephanopholis philippinensis				
Maximum				
Minimum				
Average	1	0.067		
Holotrichia flachi				
Maximum		0.067		
Minimum		0.035		
Average	6	0.056 ± 0.003	0.010 ± 0.002	18.089 ± 3.522
Anomala humeralis				
Maximum		0.106		
Minimum		0.059		
Average	7	0.085 ± 0.004	0.014 ± 0.003	16.267 ± 2.932
Autoserica nigrorubra				
Maximum		0.141		
Minimum		0.108		
Average	11	0.126 ± 0.002	0.009 ± 0.001	7.266 ± 1.045
Adoretus luridus				
Maximum		0.123		
Minimum		0.078		
Average	16	0.108 ± 0.002	0.014 ± 0.002	13.001 ± 1.550
Adoretus ranunculus				
Maximum		0.110		
Minimum		0.102		
Average	7	0.104 ± 0.001	0.005 ± 0.001	4.887 ± 0.881

TABLE 6

Measurements of right series of spiracles in Leucopholis irrorata and Lepidiota blanchardi

	NUMBER OF INDIVIDUALS	FIRST RIGHT SPIRACLE	STANDARD DEVIATION	COEFFICIENT OF VARIATION
		mm.	*mm.*	*per cent*
Leucopholis irrorata				
Maximum		0.253		
Minimum		0.034		
Average	32	0.124 ± 0.006	0.052 ± 0.004	41.708 ± 3.517
Lepidiota blanchardi				
Maximum		0.270		
Minimum		0.017		
Average	79	0.098 ± 0.004	0.058 ± 0.003	59.514 ± 3.194

	NUMBER OF INDIVIDUALS	SECOND RIGHT SPIRACLE	STANDARD DEVIATION	COEFFICIENT OF VARIATION
		mm.	*mm.*	*per cent*
Leucopholis irrorata				
Maximum		0.236		
Minimum		0.067		
Average	32	0.187 ± 0.004	0.033 ± 0.003	17.879 ± 1.507
Lepidiota blanchardi				
Maximum		0.337		
Minimum		0.101		
Average	77	0.223 ± 0.005	0.063 ± 0.003	28.122 ± 1.529

	NUMBER OF INDIVIDUALS	THIRD RIGHT SPIRACLE	STANDARD DEVIATION	COEFFICIENT OF VARIATION
		mm.	*mm.*	*per cent*
Leucopholis irrorata				
Maximum		0.152		
Minimum		0.025		
Average	32	0.110 ± 0.004	0.033 ± 0.003	29.793 ± 2.512
Lepidiota blanchardi				
Maximum		0.202		
Minimum		0.034		
Average	79	0.121 ± 0.003	0.043 ± 0.002	35.435 ± 1.901

TABLE 6 (continued)

	NUMBER OF INDIVIDUALS	FOURTH RIGHT SPIRACLE	STANDARD DEVIATION	COEFFICIENT OF VARIATION
		mm.	*mm.*	*per cent*
Leucopholis irrorata				
Maximum		0.185		
Minimum		0.017		
Average	32	0.099 ± 0.004	0.037 ± 0.003	36.980 ± 3.118
Lepidiota blanchardi				
Maximum		0.185		
Minimum		0.042		
Average	79	0.115 ± 0.003	0.035 ± 0.002	30.609 ± 1.642

	NUMBER OF INDIVIDUALS	FIFTH RIGHT SPIRACLE	STANDARD DEVIATION	COEFFICIENT OF VARIATION
		mm.	*mm.*	*per cent*
Leucopholis irrorata				
Maximum		0.143		
Minimum		0.008		
Average	32	0.076 ± 0.004	0.030 ± 0.003	39.3998 ± 3.322
Lepidiota blanchardi				
Maximum		0.169		
Minimum		0.025		
Average	79	0.094 ± 0.002	0.032 ± 0.002	33.971 ± 1.823

	NUMBER OF INDIVIDUALS	SIXTH RIGHT SPIRACLE	STANDARD DEVIATION	COEFFICIENT OF VARIATION
		mm.	*mm.*	*per cent*
Leucopholis irrorata				
Maximum		0.110		
Minimum		0.008		
Average	32	0.060 ± 0.003	0.024 ± 0.002	39.506 ± 3.331
Lepidiota blanchardi				
Maximum		0.169		
Minimum		0.017		
Average	79	0.089 ± 0.002	0.032 ± 0.002	36.053 ± 1.935

TABLE 6 (continued)

	NUMBER OF INDIVIDUALS	SEVENTH RIGHT SPIRACLE	STANDARD DEVIATION	COEFFICIENT OF VARIATION
		mm.	*mm.*	*per cent*
Leucopholis irrorata				
Maximum		0.101		
Minimum		0.017		
Average	32	0.060 ± 0.002	0.018 ± 0.002	30.345 ± 2.559
Lepidiota blanchardi				
Maximum		0.169		
Minimum		0.017		
Average	79	0.087 ± 0.003	0.037 ± 0.002	43.112 ± 2.313

	NUMBER OF INDIVIDUALS	EIGHTH RIGHT SPIRACLE	STANDARD DEVIATION	COEFFICIENT OF VARIATION
		mm.	*mm.*	*per cent*
Leucopholis irrorata				
Maximum		0.152		
Minimum		0.008		
Average	32	0.073 ± 0.004	0.029 ± 0.002	39.927 ± 3.366
Lepidiota blanchardi				
Maximum		0.185		
Minimum		0.017		
Average	78	0.091 ± 0.003	0.036 ± 0.002	39.997 ± 2.160

	NUMBER OF INDIVIDUALS	NINTH RIGHT SPIRACLE	STANDARD DEVIATION	COEFFICIENT OF VARIATION
		mm.	*mm.*	*per cent*
Leucopholis irrorata				
Maximum		0.185		
Minimum		0.034		
Average	32	0.095 ± 0.004	0.030 ± 0.003	31.574 ± 2.662
Lepidiota blanchardi				
Maximum		0.253		
Minimum		0.059		
Average	79	0.142 ± 0.003	0.045 ± 0.002	31.448 ± 1.687

TABLE 7

Measurements of parts of legs

	NUMBER OF INDIVIDUALS	LENGTH OF COXAE		
		First right leg	Standard deviation	Coefficient of variation
Leucopholis irrorata		*mm.*	*mm.*	*per cent*
Maximum		3.28		
Minimum		2.80		
Average	30	3.139 ± 0.014	0.115 ± 0.010	3.674 ± 0.320
Lepidiota blanchardi				
Maximum		3.92		
Minimum		3.20		
Average	74	3.551 ± 0.011	0.136 ± 0.008	3.819 ± 0.212
Stephanopholis philippinensis				
Maximum				
Minimum				
Average	1	1.400		
Holotrichia flachi				
Maximum		2.20		
Minimum		1.50		
Average	6	1.773 ± 0.067	0.223 ± 0.064	12.556 ± 2.445
Anomala humeralis				
Maximum		0.848		
Minimum		0.784		
Average	7	0.819 ± 0.006	0.021 ± 0.001	2.551 ± 0.460
Autoserica nigrorubra				
Maximum		0.976		
Minimum		0.880		
Average	11	0.938 ± 0.007	0.033 ± 0.007	3.550 ± 0.511
Adoretus luridus				
Maximum		0.712		
Minimum		0.648		
Average	16	0.676 ± 0.003	0.018 ± 0.003	2.712 ± 0.323
Adoretus ranunculus				
Maximum		0.760		
Minimum		0.480		
Average	7	0.642 ± 0.028	0.100 ± 0.027	15.574 ± 2.807

TABLE 7 (continued)

	NUMBER OF INDIVIDUALS	LENGTH OF COXAE		
		Second right leg	Standard deviation	Coefficient of variation
		mm.	*mm.*	*per cent*
Leucopholis irrorata				
Maximum		4.80		
Minimum		3.84		
Average	30	4.416 ± 0.030	0.239 ± 0.021	5.407 ± 0.471
Lepidiota blanchardi				
Maximum		5.68		
Minimum		4.60		
Average	74	5.272 ± 0.017	0.216 ± 0.012	4.091 ± 0.227
Stephanopholis philippinensis				
Maximum				
Minimum				
Average	1	2.000		
Holotrichia flachi				
Maximum		3.00		
Minimum		2.04		
Average	6	2.453 ± 0.092	0.304 ± 0.088	12.407 ± 2.416
Anomala humeralis				
Maximum		1.36		
Minimum		1.28		
Average	7	1.328 ± 0.008	0.028 ± 0.001	2.128 ± 0.384
Autoserica nigrorubra				
Maximum		1.328		
Minimum		1.160		
Average	11	1.279 ± 0.011	0.052 ± 0.011	4.069 ± 0.585
Adoretus luridus				
Maximum		1.320		
Minimum		1.256		
Average	16	1.283 ± 0.003	0.019 ± 0.003	1.462 ± 0.174
Adoretus ranunculus				
Maximum		1.000		
Minimum		0.880		
Average	7	0.943 ± 0.014	0.051 ± 0.014	5.381 ± 0.970

TABLE 7 (continued)

	NUMBER OF INDIVIDUALS	LENGTH OF COXAE		
		Third right leg	Standard deviation	Coefficient of variation
		mm.	*mm.*	*per cent*
Leucopholis irrorata				
Maximum		5.60		
Minimum		4.32		
Average	30	5.151 ± 0.039	0.309 ± 0.027	5.994 ± 0.522
Lepidiota blanchardi				
Maximum		6.80		
Minimum		5.52		
Average	74	6.071 ± 0.025	0.314 ± 0.017	5.166 ± 0.286
Stephanopholis philippinensis				
Maximum				
Minimum				
Average	1	2.600		
Holotrichia flachi				
Maximum		3.84		
Minimum		2.82		
Average	6	3.193 ± 0.098	0.032 ± 0.009	1.015 ± 0.198
Anomala humeralis				
Maximum		1.984		
Minimum		1.760		
Average	7	1.872 ± 0.020	0.071 ± 0.019	3.797 ± 0.684
Autoserica nigrorubra				
Maximum		1.648		
Minimum		1.504		
Average	11	1.578 ± 0.011	0.052 ± 0.011	3.293 ± 0.474
Adoretus luridus				
Maximum		1.824		
Minimum		1.712		
Average	16	1.759 ± 0.006	0.033 ± 0.006	1.863 ± 0.222
Adoretus ranunculus				
Maximum		1.360		
Minimum		1.240		
Average	7	1.311 ± 0.011	0.040 ± 0.011	3.067 ± 0.553

TABLE 7 (continued)

	NUMBER OF INDIVIDUALS	LENGTH OF FEMORA		
		First right leg	Standard deviation	Coefficient of variation
		mm.	*mm.*	*per cent*
Leucopholis irrorata				
Maximum		2.48		
Minimum		2.08		
Average	30	2.325 ± 0.015	0.122 ± 0.011	5.249 ± 0.457
Lepidiota blanchardi				
Maximum		3.20		
Minimum		2.48		
Average	74	2.852 ± 0.013	0.168 ± 0.009	5.896 ± 0.327
Stephanopholis philippinensis				
Maximum				
Minimum				
Average	1	1.40		
Holotrichia flachi				
Maximum		1.88		
Minimum		1.60		
Average	6	1.703 ± 0.030	0.099 ± 0.029	5.799 ± 1.129
Anomala humeralis				
Maximum		0.840		
Minimum		0.656		
Average	7	0.719 ± 0.017	0.060 ± 0.016	8.336 ± 1.503
Autoserica nigrorubra				
Maximum		0.76		
Minimum		0.64		
Average	11	0.713 ± 0.007	0.032 ± 0.007	4.509 ± 0.648
Adoretus luridus				
Maximum		0.688		
Minimum		0.576		
Average	16	0.636 ± 0.005	0.027 ± 0.005	4.312 ± 0.514
Adoretus ranunculus				
Maximum		0.704		
Minimum		0.560		
Average	7	0.633 ± 0.011	0.041 ± 0.011	6.460 ± 1.165

TABLE 7 (continued)

	NUMBER OF INDIVIDUALS	LENGTH OF FEMORA		
		Second right leg	Standard deviation	Coefficient of variation
		mm.	*mm.*	*per cent*
Leucopholis irrorata				
Maximum		2.80		
Minimum		2.08		
Average	30	2.489 ± 0.027	0.219 ± 0.019	8.778 ± 0.764
Lepidiota blanchardi				
Maximum		3.80		
Minimum		2.80		
Average	74	3.309 ± 0.018	0.226 ± 0.013	6.815 ± 0.378
Stephanopholis philippinensis				
Maximum				
Minimum				
Average	1	1.52		
Holotrichia flachi				
Maximum		1.96		
Minimum		1.50		
Average	6	1.713 ± 0.042	0.138 ± 0.040	8.015 ± 1.568
Anomala humeralis				
Maximum		0.896		
Minimum		0.816		
Average	7	0.866 ± 0.007	0.026 ± 0.007	3.033 ± 0.547
Autoserica nigrorubra				
Maximum		0.880		
Minimum		0.736		
Average	11	0.794 ± 0.009	0.041 ± 0.009	5.103 ± 0.734
Adoretus luridus				
Maximum		0.896		
Minimum		0.816		
Average	16	0.860 ± 0.004	0.024 ± 0.004	2.791 ± 0.333
Adoretus ranunculus				
Maximum		0.800		
Minimum		0.704		
Average	7	0.737 ± 0.009	0.032 ± 0.008	4.281 ± 0.772

TABLE 7 (continued)

	NUMBER OF INDIVIDUALS	LENGTH OF FEMORA		
		Third right leg	Standard deviation	Coefficient of variation
		mm.	*mm.*	*per cent*
Leucopholis irrorata				
Maximum		3.00		
Minimum		2.32		
Average	30	2.697 ± 0.025	0.200 ± 0.017	7.421 ± 0.646
Lepidiota blanchardi				
Maximum		3.80		
Minimum		2.88		
Average	74	3.395 ± 0.018	0.232 ± 0.013	6.831 ± 0.379
Stephanopholis philippinensis				
Maximum				
Minimum				
Average	1	1.64		
Holotrichia flachi				
Maximum		2.00		
Minimum		1.64		
Average	6	1.800 ± 0.033	0.108 ± 0.031	6.017 ± 1.172
Anomala humeralis				
Maximum		0.912		
Minimum		0.848		
Average	7	0.883 ± 0.006	0.021 ± 0.006	2.366 ± 0.426
Autoserica nigrorubra				
Maximum		0.960		
Minimum		0.816		
Average	11	0.880 ± 0.008	0.036 ± 0.008	4.136 ± 0.595
Adoretus luridus				
Maximum		1.104		
Minimum		0.848		
Average	16	0.972 ± 0.012	0.069 ± 0.012	7.062 ± 0.842
Adoretus ranunculus				
Maximum		0.864		
Minimum		0.720		
Average	7	0.774 ± 0.014	0.052 ± 0.014	1.789 ± 0.322

TABLE 7 (continued)

	NUMBER OF INDIVIDUALS	LENGTH OF TIBIAE		
		First right leg	Standard deviation	Coefficient of variation
		mm.	*mm.*	*per cent*
Leucopholis irrorata				
Maximum		2.20		
Minimum		1.84		
Average	30	1.993 ± 0.011	0.091 ± 0.008	4.549 ± 0.396
Lepidiota blanchardi				
Maximum		2.60		
Minimum		2.00		
Average	74	2.332 ± 0.010	0.124 ± 0.007	5.319 ± 0.295
Stephanopholis philippinensis				
Maximum				
Minimum				
Average	1	1.16		
Holotrichia flachi				
Maximum		1.60		
Minimum		1.30		
Average	6	1.450 ± 0.004	0.012 ± 0.003	0.803 ± 0.156
Anomala humeralis				
Maximum		0.688		
Minimum		0.560		
Average	7	0.638 ± 0.011	0.016 ± 0.004	2.533 ± 0.457
Autoserica nigrorubra				
Maximum		0.784		
Minimum		0.608		
Average	11	0.730 ± 0.010	0.046 ± 0.010	6.353 ± 0.914
Adoretus luridus				
Maximum		0.720		
Minimum		0.520		
Average	16	0.632 ± 0.008	0.045 ± 0.008	7.175 ± 0.855
Adoretus ranunculus				
Maximum		0.672		
Minimum		0.528		
Average	7	0.599 ± 0.014	0.050 ± 0.013	8.430 ± 1.520

TABLE 7 (continued)

	NUMBER OF INDIVIDUALS	LENGTH OF TIBIAE		
		Second right leg	Standard deviation	Coefficient of variation
		mm.	*mm.*	*per cent*
Leucopholis irrorata				
Maximum		2.28		
Minimum		1.80		
Average	30	2.011 ± 0.018	0.142 ± 0.012	7.042 ± 0.613
Lepidiota blanchardi				
Maximum		2.72		
Minimum		2.08		
Average	74	2.386 ± 0.012	0.156 ± 0.009	6.542 ± 0.363
Stephanopholis philippinensis				
Maximum				
Minimum				
Average	1	1.16		
Holotrichia flachi				
Maximum		1.72		
Minimum		1.44		
Average	6	1.617 ± 0.028	0.091 ± 0.026	5.642 ± 1.098
Anomala humeralis				
Maximum		0.720		
Minimum		0.592		
Average	7	0.663 ± 0.011	0.040 ± 0.001	6.031 ± 1.087
Autoserica nigrorubra				
Maximum		0.880		
Minimum		0.720		
Average	11	0.810 ± 0.009	0.041 ± 0.009	5.019 ± 0.722
Adoretus luridus				
Maximum		0.800		
Minimum		0.640		
Average	16	0.714 ± 0.008	0.043 ± 0.008	6.050 ± 0.721
Adoretus ranunculus				
Maximum		0.720		
Minimum		0.624		
Average	7	0.680 ± 0.010	0.037 ± 0.010	5.445 ± 0.982

TABLE 7 (continued)

	NUMBER OF INDIVIDUALS	LENGTH OF TIBIAE		
		Third right leg	Standard deviation	Coefficient of variation
Leucopholis irrorata		*mm.*	*mm.*	*per cent*
Maximum		2.00		
Minimum		1.52		
Average	30	1.779 ± 0.019	0.152 ± 0.013	8.549 ± 0.744
Lepidiota blanchardi				
Maximum		2.64		
Minimum		1.92		
Average	74	2.336 ± 0.012	0.156 ± 0.009	6.697 ± 0.371
Stephanopholis philippinensis				
Maximum				
Minimum				
Average	1	1.12		
Holotrichia flachi				
Maximum		1.64		
Minimum		1.24		
Average	6	1.477 ± 0.042	0.138 ± 0.040	9.330 ± 1.817
Anomala humeralis				
Maximum		0.720		
Minimum		0.672		
Average	7	0.701 ± 0.004	0.016 ± 0.004	2.272 ± 0.410
Autoserica nigrorubra				
Maximum		0.720		
Minimum		0.624		
Average	11	0.666 ± 0.007	0.031 ± 0.007	4.584 ± 0.659
Adoretus luridus				
Maximum		0.896		
Minimum		0.656		
Average	16	0.800 ± 0.010	0.057 ± 0.010	7.133 ± 0.850
Adoretus ranunculus				
Maximum		0.736		
Minimum		0.576		
Average	7	0.683 ± 0.016	0.057 ± 0.015	8.280 ± 1.493

TABLE 8

Measurements of claws

	NUMBER OF INDIVIDUALS	LENGTH OF CLAW OF FIRST RIGHT LEG	STANDARD DEVIATION	COEFFICIENT OF VARIATION
		mm.	*mm.*	*per cent*
Leucopholis irrorata				
Maximum		1.222		
Minimum		0.859		
Average	30	0.980 ± 0.009	0.023 ± 0.002	2.329 ± 0.203
Lepidiota blanchardi				
Maximum		1.489		
Minimum		0.916		
Average	74	1.188 ± 0.009	0.112 ± 0.006	9.405 ± 0.521
Stephanopholis philippinensis				
Maximum				
Minimum				
Average	1	0.422		
Holotrichia flachi				
Maximum		0.607		
Minimum		0.540		
Average	6	0.577 ± 0.007	0.024 ± 0.007	4.108 ± 0.800
Anomala humeralis				
Maximum		0.413		
Minimum		0.346		
Average	7	0.384 ± 0.007	0.025 ± 0.007	6.515 ± 1.175
Autoserica nigrorubra				
Maximum		0.405		
Minimum		0.337		
Average	11	0.366 ± 0.004	0.018 ± 0.004	4.942 ± 0.711
Adoretus luridus				
Maximum		0.438		
Minimum		0.371		
Average	16	0.404 ± 0.004	0.021 ± 0.004	5.158 ± 0.615
Adoretus ranunculus				
Maximum		0.346		
Minimum		0.312		
Average	7	0.328 ± 0.003	0.011 ± 0.003	3.487 ± 0.629

TABLE 8 (continued)

	NUMBER OF INDIVIDUALS	LENGTH OF CLAW OF SECOND RIGHT LEG	STANDARD DEVIATION	COEFFICIENT OF VARIATION
		mm.	*mm.*	*per cent*
Leucopholis irrorata				
Maximum		1.145		
Minimum		0.802		
Average	30	0.987 ± 0.009	0.022 ± 0.002	2.279 ± 0.198
Lepidiota blanchardi				
Maximum		1.623		
Minimum		0.897		
Average	74	1.186 ± 0.013	0.163 ± 0.009	13.752 ± 0.762
Stephanopholis philippinensis				
Maximum				
Minimum				
Average	1	0.354		
Holotrichia flachi				
Maximum		0.826		
Minimum		0.523		
Average	6	0.639 ± 0.028	0.094 ± 0.027	1.469 ± 0.286
Anomala humeralis				
Maximum		0.422		
Minimum		0.337		
Average	7	0.373 ± 0.008	0.029 ± 0.008	7.702 ± 1.388
Autoserica nigrorubra				
Maximum		0.422		
Minimum		0.362		
Average	11	0.393 ± 0.004	0.018 ± 0.004	4.597 ± 0.661
Adoretus luridus				
Maximum		0.472		
Minimum		0.405		
Average	16	0.435 ± 0.003	0.020 ± 0.003	4.485 ± 0.535
Adoretus ranunculus				
Maximum		0.438		
Minimum		0.354		
Average	7	0.389 ± 0.008	0.028 ± 0.008	7.274 ± 1.311

TABLE 8 (continued)

	NUMBER OF INDIVIDUALS	LENGTH OF CLAW OF THIRD RIGHT LEG	STANDARD DEVIATION	COEFFICIENT OF VARIATION
		mm.	*mm.*	*per cent*
Leucopholis irrorata				
Maximum		0.477		
Minimum		0.248		
Average	30	0.367 ± 0.007	0.053 ± 0.005	14.375 ± 1.252
Lepidiota blanchardi				
Maximum		0.535		
Minimum		0.191		
Average	74	0.382 ± 0.006	0.075 ± 0.004	19.636 ± 1.089
Stephanopholis philippinensis				
Maximum				
Minimum				
Average	1	0.211		
Holotrichia flachi				
Maximum		0.379		
Minimum		0.253		
Average	6	0.302 ± 0.014	0.047 ± 0.013	1.541 ± 0.300
Anomala humeralis				
Maximum		0.270		
Minimum		0.236		
Average	7	0.252 ± 0.003	0.009 ± 0.003	3.767 ± 0.679
Autoserica nigrorubra				
Maximum		0.160		
Minimum		0.135		
Average	11	0.146 ± 0.002	0.008 ± 0.002	5.639 ± 0.811
Adoretus luridus				
Maximum		0.455		
Minimum		0.405		
Average	16	0.430 ± 0.003	0.016 ± 0.003	3.694 ± 0.441
Adoretus ranunculus				
Maximum		0.438		
Minimum		0.295		
Average	7	0.378 ± 0.012	0.014 ± 0.004	3.776 ± 0.681

TABLE 9

Setae on last abdominal sternite

	NUMBER OF INDIVIDUALS	NUMBER OF SETAE TO A ROW OF TWO ROWS	STANDARD DEVIATION	COEFFICIENT OF VARIATION
				per cent
Leucopholis irrorata				
Maximum		21		
Minimum		14		
Average	32	19.031 ± 0.170	1.403 ± 1.183	7.371 ± 0.622
Lepidiota blanchardi				
Maximum		31		
Minimum		14		
Average	79	20.937 ± 0.279	3.651 ± 0.196	17.438 ± 0.936
Stephanopholis philippinensis				
Maximum				
Minimum				
Average	1	20		
Holotrichia flachi				
Maximum		25		
Minimum		24		
Average	6	24.5 ± 0.151	0.500 ± 0.097	2.041 ± 0.397
Anomala humeralis				
Maximum		10		
Minimum		9		
Average	7	9.143 ± 0.096	0.350 ± 0.063	3.827 ± 0.690
Autoserica nigrorubra				
Maximum		21[b] (75)[a]		
Minimum		20 (62)[a]		
Average	11	20.364 ± 0.103[b] (67.182±0.907)[a]	0.481 ± 0.069[b] (4.251±0.611)[a]	2.362 ± 0.340[b] (0.910±0.131)[a]
Adoretus luridus				
Maximum		82		
Minimum		70		
Average	16	74.625 ± 0.309	3.603 ± 0.430	4.828 ± 0.576
Adoretus ranunculus				
Maximum		53		
Minimum		48		
Average	7	49.86 ± 0.445	1.641 ± 0.439	0.880 ± 0.159

[a] Remainder of radula
[b] Arc

TABLE 9 (continued)

	NUMBER OF INDIVIDUALS	AVERAGE LENGTH OF SETAE IN ROWS	STANDARD DEVIATION	COEFFICIENT OF VARIATION
		mm.	*mm.*	*per cent*
Leucopholis irrorata				
Maximum		0.523		
Minimum		0.253		
Average	167	0.376 ± 0.003	0.056 ± 0.003	14.820 ± 0.547
Lepidiota blanchardi				
Maximum		0.354		
Minimum		0.169		
Average	152	0.259 ± 0.002	0.039 ± 0.002	15.236 ± 0.589
Stephanopholis philippinensis				
Maximum		0.169		
Minimum		0.084		
Average	39	0.117 ± 0.002	0.016 ± 0.002	13.592 ± 1.038
Holotrichia flachi				
Maximum		0.161		
Minimum		0.088		
Average	147	0.138 ± 0.0008	0.013 ± 0.008	9.494 ± 0.373
Anomala humeralis				
Maximum		0.263		
Minimum		0.082		
Average	74	0.179 ± 0.004	0.165 ± 0.014	91.692 ± 5.084
Autoserica nigrorubra				
Maximum		0.196		
Minimum		0.118		
Average	86	0.169 ± 0.001	0.014 ± 0.001	8.505 ± 0.437
Adoretus luridus				
Maximum		0.180		
Minimum		0.098		
Average	152	[c] 0.147 ± 0.001	0.019 ± 0.001	13.127 ± 0.508
Adoretus ranunculus				
Maximum		0.163		
Minimum		0.102		
Average	136	[d] 0.131 ± 0.001	0.015 ± 0.001	11.639 ± 0.476

[c, d] Setae on radula

TABLE 9 (continued)

	NUMBER OF INDIVIDUALS	AVERAGE WIDTH OF SETAE IN ROWS AT BASE	STANDARD DEVIATION	COEFFICIENT OF VARIATION
		mm.	*mm.*	*per cent*
Leucopholis irrorata				
Maximum		0.051		
Minimum		0.034		
Average	167	0.043 ± 0.0003	0.006 ± 0.0003	12.790 ± 0.472
Lepidiota blanchardi				
Maximum		0.084		
Minimum		0.051		
Average	152	0.066 ± 0.0004	0.007 ± 0.0004	10.119 ± 0.391
Stephanopholis philippinensis				
Maximum		0.034		
Minimum		0.025		
Average	39	0.032 ± 0.0004	0.003 ± 0.0004	9.735 ± 0.744
Holotrichia flachi				
Maximum		0.039		
Minimum		0.029		
Average	147	0.036 ± 0.0001	0.002 ± 0.0001	6.865 ± 0.270
Anomala humeralis				
Maximum		0.025		
Minimum		0.020		
Average	74	0.023 ± 0.002	0.022 ± 0.002	96.045 ± 5.325
Autoserica nigrorubra				
Maximum		0.029		
Minimum		0.020		
Average	86	0.024 ± 0.0002	0.003 ± 0.0002	10.532 ± 0.542
Adoretus luridus				
Maximum		0.039		
Minimum		0.022		
Average	152	0.032 ± 0.0002	0.004 ± 0.0002	13.518 ± 0.523
Adoretus ranunculus				
Maximum		0.039		
Minimum		0.016		
Average	136	0.025 ± 0.0003	0.005 ± 0.0003	20.361 ± 0.833

TABLE 9 (continued)

	NUMBER OF INDIVIDUALS	LENGTH OF SETAE OUTSIDE OF ROWS	STANDARD DEVIATION	COEFFICIENT OF VARIATION
		mm.	*mm.*	*per cent*
Leucopholis irrorata				
Maximum		0.725		
Minimum		0.219		
Average	147	0.462 ± 0.007	0.123 ± 0.007	26.669 ± 1.049
Lepidiota blanchardi				
Maximum		1.130		
Minimum		0.228		
Average	147	0.566 ± 0.010	0.054 ± 0.003	9.569 ± 0.376
Stephanopholis philippinensis				
Maximum		0.287		
Minimum		0.135		
Average	45	0.196 ± 0.001	0.037 ± 0.004	18.744 ± 1.333
Holotrichia flachi				
Maximum		0.303		
Minimum		0.169		
Average	151	0.260 ± 0.0005	0.028 ± 0.002	10.674 ± 0.414
Anomala humeralis				
Maximum		0.265		
Minimum		0.078		
Average	82	0.170 ± 0.003	0.044 ± 0.003	26.042 ± 1.372
Autoserica nigrorubra				
Maximum		0.104		
Minimum		0.059		
Average	88	0.075 ± 0.001	0.012 ± 0.001	15.603 ± 0.793
Adoretus luridus				
Maximum				
Minimum				
Average				
Adoretus ranunculus				
Maximum				
Minimum				
Average				

TABLE 9 (continued)

	NUMBER OF INDIVIDUALS	WIDTH OF SETAE OUTSIDE OF ROWS	STANDARD DEVIATION	COEFFICIENT OF VARIATION
		mm.	*mm.*	*per cent*
Leucopholis irrorata				
Maximum		0.101		
Minimum		0.051		
Average	147	0.072 ± 0.0006	0.010 ± 0.001	14.581 ± 0.574
Lepidiota blanchardi				
Maximum		0.101		
Minimum		0.042		
Average	147	0.061 ± 0.0008	0.015 ± 0.0009	24.315 ± 0.956
Stephanopholis philippinensis				
Maximum		0.076		
Minimum		0.042		
Average	45	0.054 ± 0.001	0.010 ± 0.001	18.954 ± 1.348
Holotrichia flachi				
Maximum		0.051		
Minimum		0.025		
Average	151	0.036 ± 0.0004	0.007 ± 0.0004	20.872 ± 0.810
Anomala humeralis				
Maximum		0.045		
Minimum		0.020		
Average	82	0.031 ± 0.0005	0.006 ± 0.0005	19.252 ± 1.014
Autoserica nigrorubra				
Maximum		0.027		
Minimum		0.018		
Average	88	0.023 ± 0.0002	0.003 ± 0.0002	12.572 ± 0.639
Adoretus luridus				
Maximum				
Minimum				
Average				
Adoretus ranunculus				
Maximum				
Minimum				
Average				

MORPHOLOGICAL DETAILS OF WHITE GRUBS

[Magnifications indicated refer to original figures]

PLATE 1

Leucopholis irrorata Chevrolat

Fig. 1. Larva, sinistral aspect. × 6.
2. Head, frontal aspect. × 14.
3. Epicranium, dextral aspect. × 20.
4. Mouth parts in situ, dextral aspect. × 12.
5. Labrum, ectal aspect. × 20.
6. Epipharynx and hypopharynx. × 12.
7. Epipharynx. × 12.
8. Mandible, left, ectal aspect. × 12.
9. Mandible, right, ectal aspect. × 12.
10. Mandible, left, ental aspect. × 12.
11. Mandible, right, ental aspect. × 12.
12. Dorsal articulation of right mandible. × 6.
13. Relative position of mandibles with hypopharynx. × 12.

PLATE 2

Leucopholis irrorata Chevrolat

14. Maxilla, right, ectal aspect. × 12.
15. Maxilla, right, ental aspect. × 12.
16. Ectal articulation of right maxilla. × 6.
17. Maxillary scraper, right. × 64.
18. Details of teeth of maxillary scraper, right. × 150.
19. Labium, ectal aspect. × 12.
20. Antenna, right. × 12.
21. Tip of right antenna. × 150.
22. Spiracle, first right. × 90.
23. Surface of peritreme of first right spiracle. × 660.
24. Fore leg, right. × 12.
25. Middle leg, right. × 12.
26. Hind leg, right. × 12.
27. Claw, fore leg, right. × 90.
28. Claw, middle leg, right. × 90.
29. Claw, hind leg, right. × 90.
30. Caudal portion of abdomen, ventral aspect. × 6.
31. Radula. × 34.

PLATE 3

Lepidiota blanchardi Dalla Torre

Fig. 1. Larva, sinistral aspect. × 6.
2. Head, frontal aspect. × 14.
3. Epicranium, dextral aspect. × 20.
4. Mouth parts in situ, dextral aspect. × 12.

5. Labrum, ectal aspect. × 20.
6. Epipharynx and hypopharynx. × 12.
7. Hypopharynx. × 12.
8. Epipharynx. × 12.
9. Mandible, left, ectal aspect. × 12.
10. Mandible, right, ectal aspect. × 12.
11. Mandible, left, ental aspect. × 12.
12. Mandible, right ental aspect. × 12.
13. Dorsal articulation of right mandible. × 20.
14. Relative position of mandibles with hypopharynx. × 12.
15. Maxilla, right, ectal aspect. × 12.
16. Maxilla, right, ental aspect. × 12.
17. Ectal articulation of right maxilla. × 90.
18. Maxillary scraper, right. × 64.
19. Details of teeth of maxillary scraper, right. × 150.
20. Labium, ectal aspect. × 12.

PLATE 4

Lepidiota blanchardi Dalla Torre

21. Antennae, right. × 12.
22. Tip of right antenna.
23. Spiracle, first right. × 90.
24. Surface of peritreme of first right spiracle. × 660.
25. Fore leg, right. × 12.
26. Middle leg, right. × 12.
27. Hind leg, right. × 12.
28. Claw, fore leg. × 90.
29. Claw, middle leg. × 90.
30. Claw, hind leg. × 90.
31. Caudal portion of abdomen, ventral aspect. × 6.
32. Radula. × 34.

PLATE 5

Stephanopholis philippinensis Brenske, second instar

Fig. 1. Larva, sinistral aspect. × 6.
2. Head, frontal aspect. × 34.
3. Epipharynx. × 36.
4. Mandible, left, ectal aspect. × 34.
5. Mandible, right, ectal aspect. × 34.
6. Mandible, right, ental aspect. × 34.
7. Mandible, left, ental aspect. × 34.
8. Maxilla, right, ectal aspect. × 34.
9. Maxilla, right, ental aspect. × 34.
10. Maxillary scraper, right. × 150.
11. Maxillary scraper, portion of right. × 660.
12. Spiracle, first right. × 330.
13. Claw of fore leg, right. × 90.

14. Claw of middle leg, right. × 90.
15. Claw of hind leg, right. × 90.
16. Caudal portion of abdomen, ventral aspect. × 12.
17. Radula. × 64.

PLATE 6

Holotrichia flachi Brenske

Fig. 1. Larva, sinistral aspect. × 6.
2. Head, frontal aspect. × 34.
3. Epipharynx. × 36.
4. Mandible, left, ectal aspect. × 20.
5. Mandible, right, ectal aspect. × 20.
6. Mandible, left, ental aspect. × 20.
7. Mandible, right, ental aspect. × 20.
8. Maxilla, right, ectal aspect. × 36.
9. Maxilla, right, ental aspect. × 36.
10. Maxillary scraper, right. × 90.
11. Maxillary scraper, portion of right. × 396.
12. Spiracle, first right. × 330.
13. Claw, fore leg, right. × 90.
14. Claw, middle leg, right. × 90.
15. Claw, hind leg, right. × 90.
16. Caudal portion of abdomen, ventral aspect. × 12.
17. Radula. × 64.

PLATE 7

Autoserica nigrorubra Brenske

Fig. 1. Larva, sinistral aspect. ×6.
2. Head, frontal aspect. × 34.
3. Epipharynx. × 36.
4. Mandible, left, ectal aspect. × 36.
5. Mandible, right, ectal aspect. × 36.
6. Mandible, left, ental aspect. × 36.
7. Mandible, right, ental aspect. × 36.
8. Maxilla, right, ectal aspect. × 64.
9. Maxilla, right, ental aspect. × 64.
10. Maxillary scraper, right. × 150.
11. Maxillary scraper, portion of right. × 660.
12. Spiracle, first right. × 330.
13. Claw, fore leg, right. × 90.
14. Claw, middle leg, right. × 90.
15. Claw, hind leg, right. × 90.
16. Caudal portion of abdomen, ventral aspect. × 12.
17. Radula. × 64.

PLATE 8

Anomala humeralis Burmeister

Fig. 1. Larva, sinistral aspect. × 6.
2. Head, frontal aspect. × 34.

3. Epipharynx. × 36.
4. Mandible, left, ectal aspect. × 36.
5. Mandible, right, ectal aspect. × 36.
6. Mandible, left, ental aspect. × 36.
7. Mandible, right, ental aspect. × 36.
8. Maxilla, right, ectal aspect. × 36.
9. Maxilla, right, ental aspect. × 36.
10. Maxillary scraper, right. × 150.
11. Maxillary scraper, portion of right. ×660.
12. Spiracle, first right. × 330.
13. Claw, fore leg, right. × 90.
14. Claw, middle leg, right. × 90.
15. Claw, hind leg, right. × 90.
16. Caudal portion of abdomen, ventral aspect. × 12.
17. Radula. × 64.

PLATE 9

Adoretus luridus Blanchard

Fig. 1. Larva, sinistral aspect. × 6.
2. Head, frontal aspect. × 34.
3. Epipharynx. × 36.
4. Mandible, left, ectal aspect. × 36.
5. Mandible, right, ectal aspect. × 36.
6. Mandible, left, ental aspect. × 36.
7. Mandible, right, ental aspect. × 36.
8. Maxilla, right, ectal aspect. × 36.
9. Maxilla, right, ental aspect. × 36.
10. Maxillary scraper, right. × 150.
11. Maxillary scraper, portion of right. × 660.
12. Spiracle, first right. × 330.
13. Claw, fore leg, right. × 90.
14. Claw, middle leg, right. × 90.
15. Claw, hind leg, right. × 90.
16. Caudal portion of abdomen, ventral aspect. × 12.
17. Radula. × 64.

PLATE 10

Adoretus (*Lepadoretus*) *ranunculus* Burmeister

Fig. 1. Larva, sinistral aspect. × 6.
2. Head, frontal aspect. × 34.
3. Epipharynx. × 36.
4. Mandible, left, ectal aspect. × 36.
5. Mandible, right, ectal aspect. × 36.
6. Mandible, left, ental aspect. × 36.

7. Mandible, right, ental aspect. × 36.
8. Maxilla, right, ectal aspect. × 64.
9. Maxilla, right, ental aspect. × 64.
10. Maxillary scraper, right. × 150.
11. Maxillary scraper, portion of right. × 660.
12. Spiracle, first right. × 330.
13. Claw, fore leg, right. × 90.
14. Claw, middle leg, right. × 90
15. Claw, hind leg, right. × 90.
16. Caudal portion of abdomen, ventral aspect. × 12.
17. Radula. × 64.

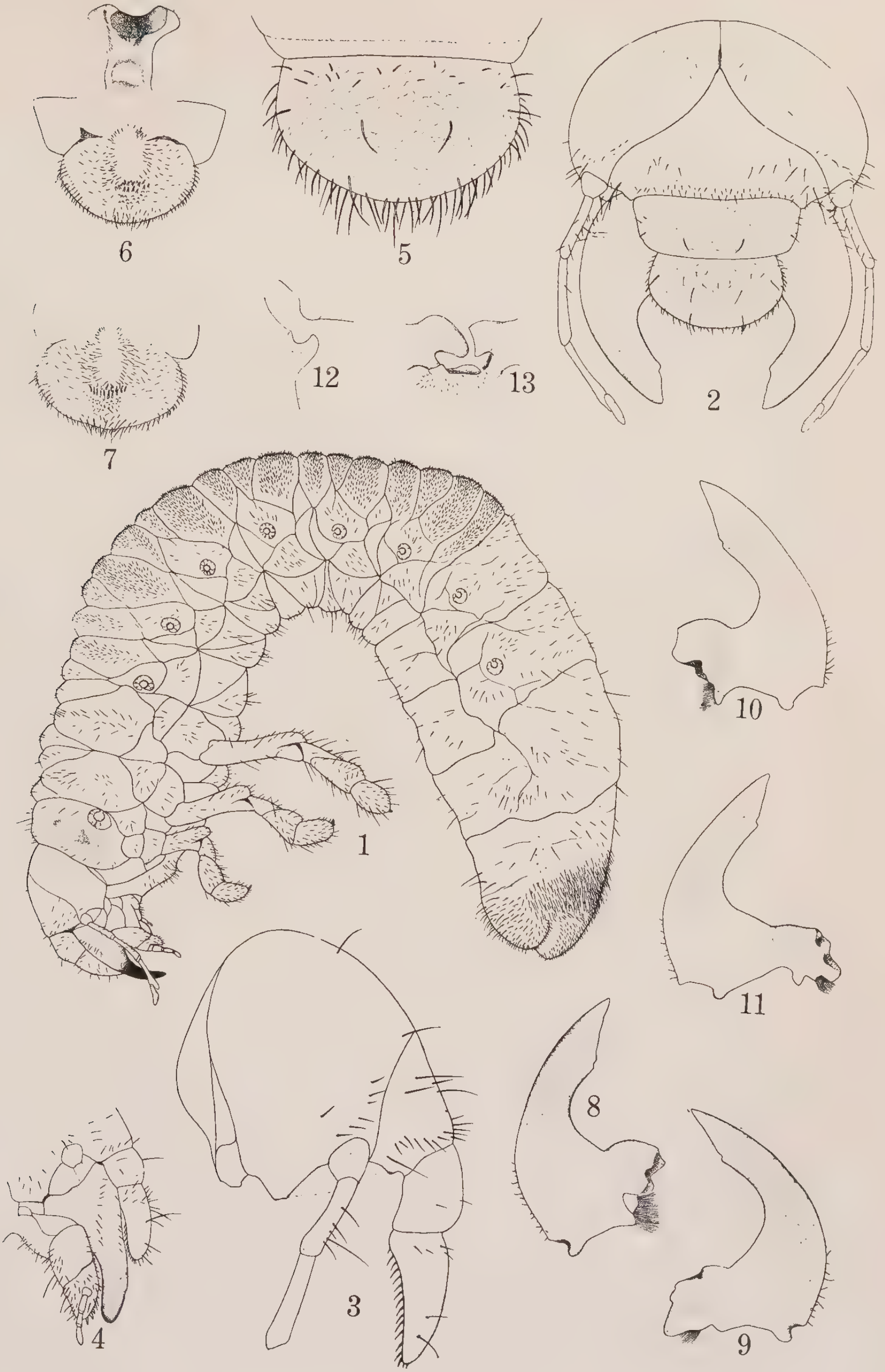
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PLATE 1
Leucopholis irrorata Chevrolat

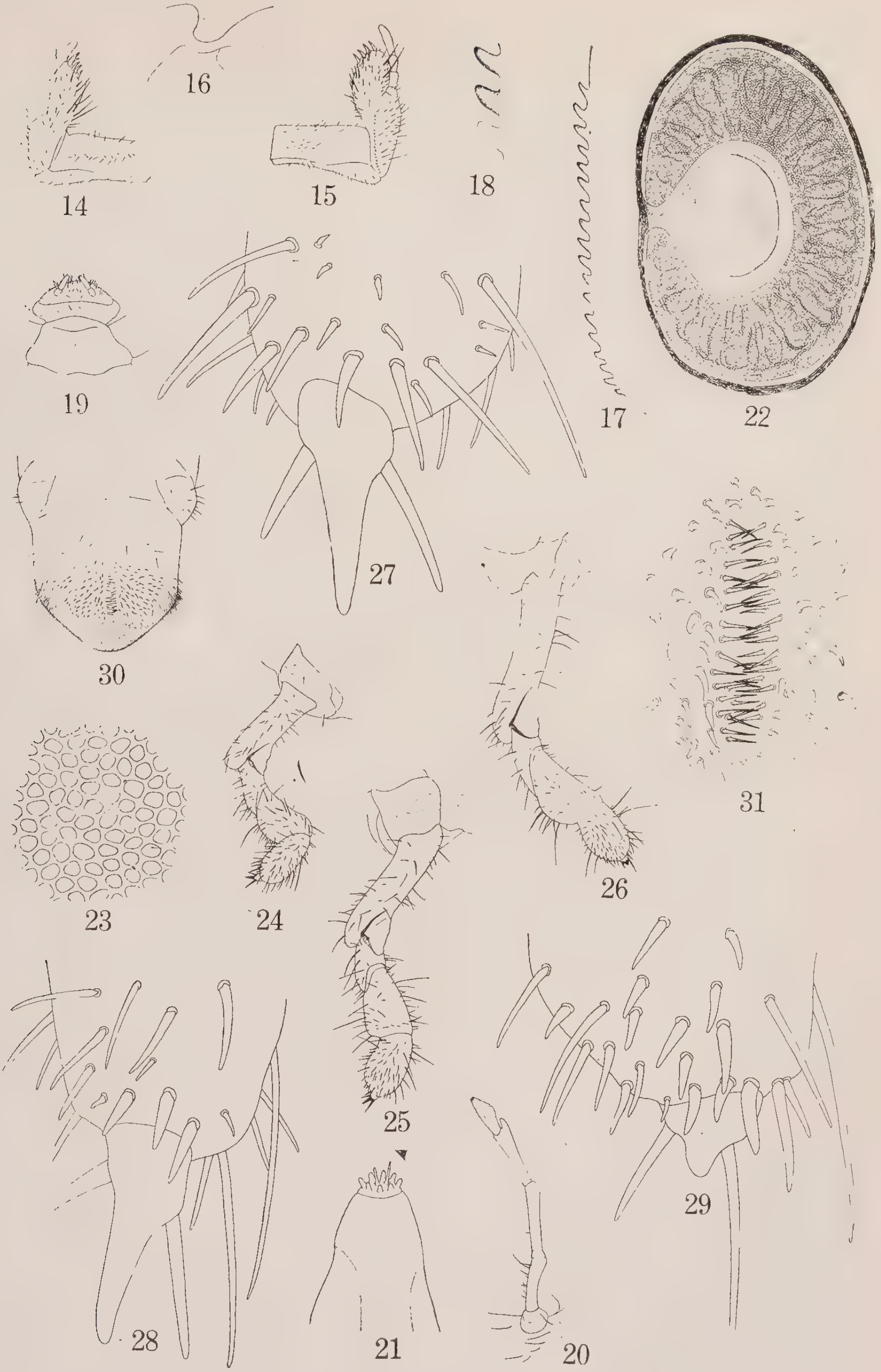
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PLATE 2
Leucopholis irrorata Chevrolat

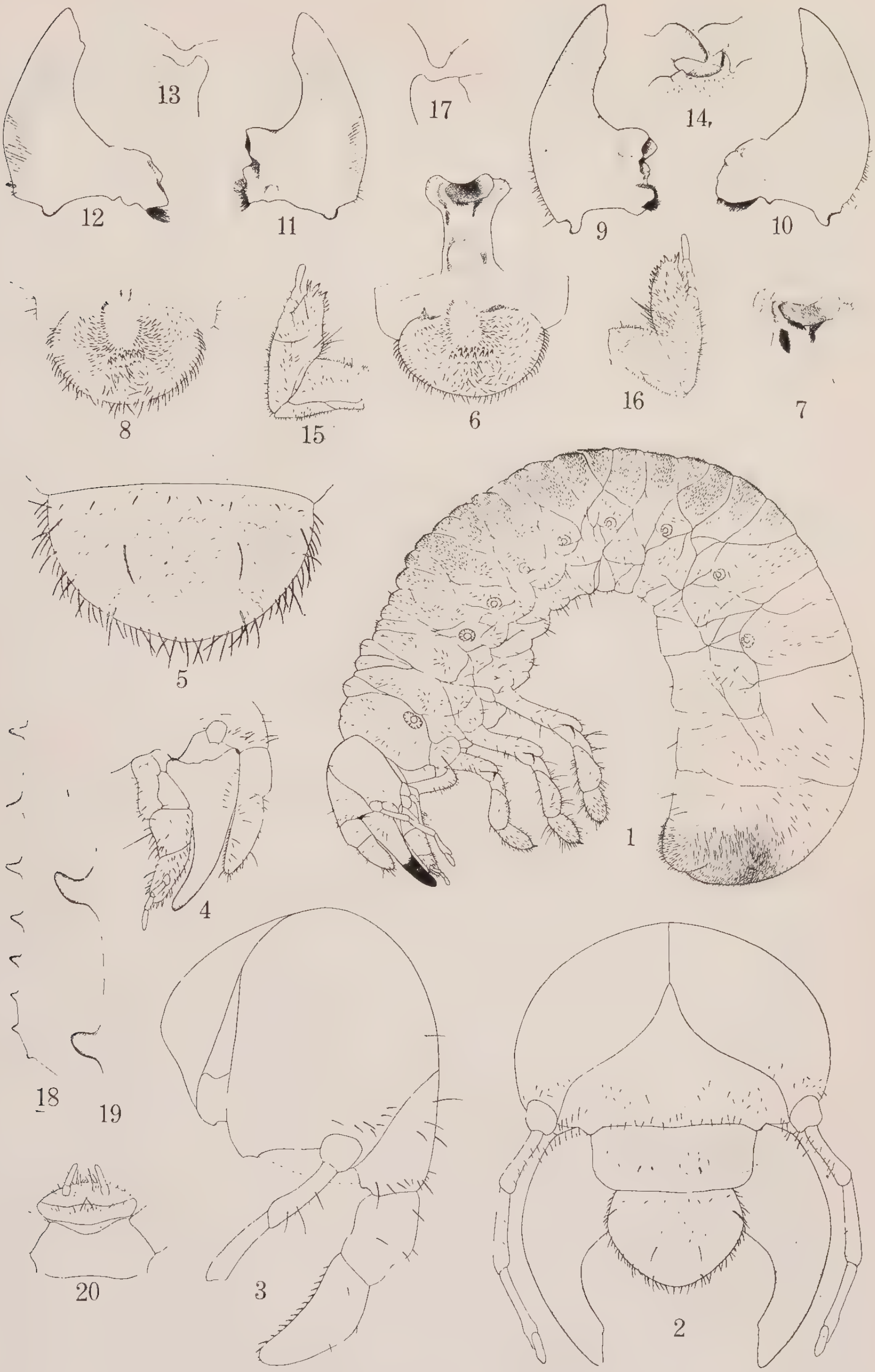
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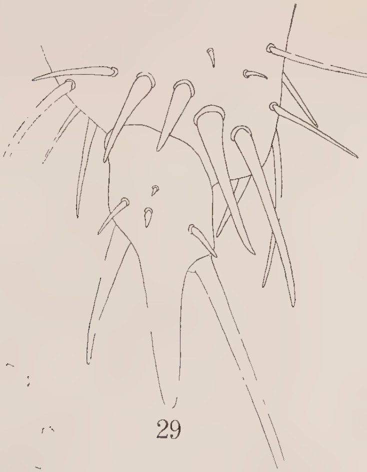
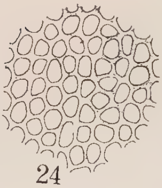
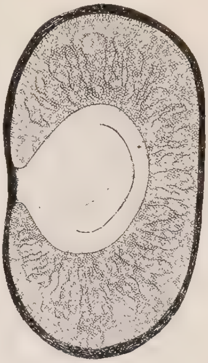
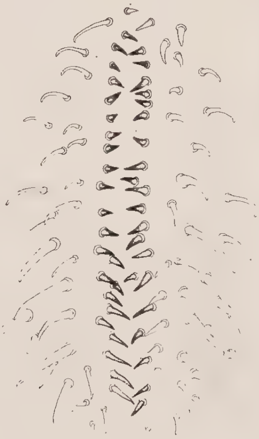
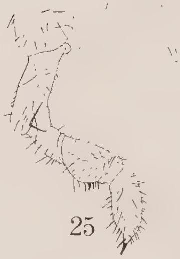
PLATE 3
Lepidiota blanchardi Dalla Torre

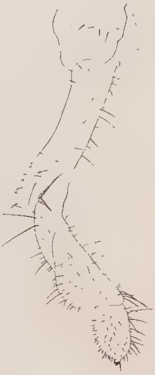


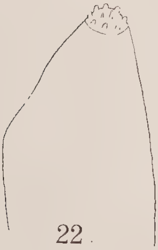


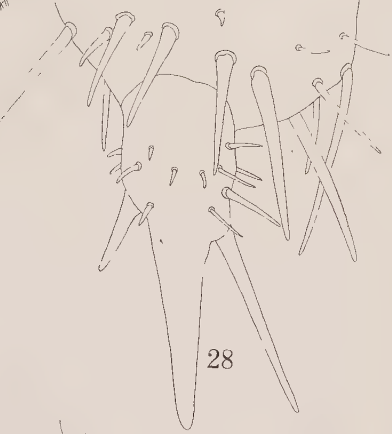


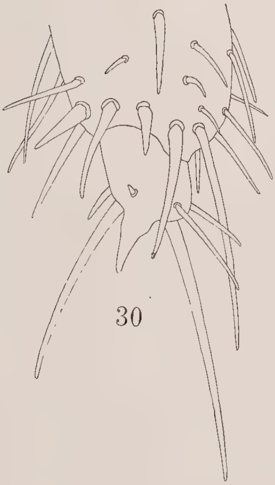


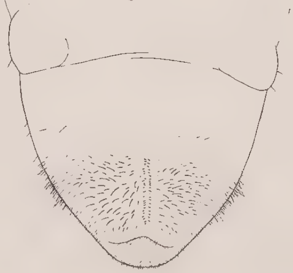












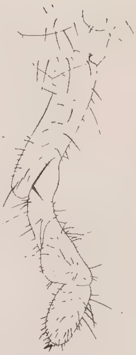


PLATE 4
Lepidiota blanchardi Dalla Torre

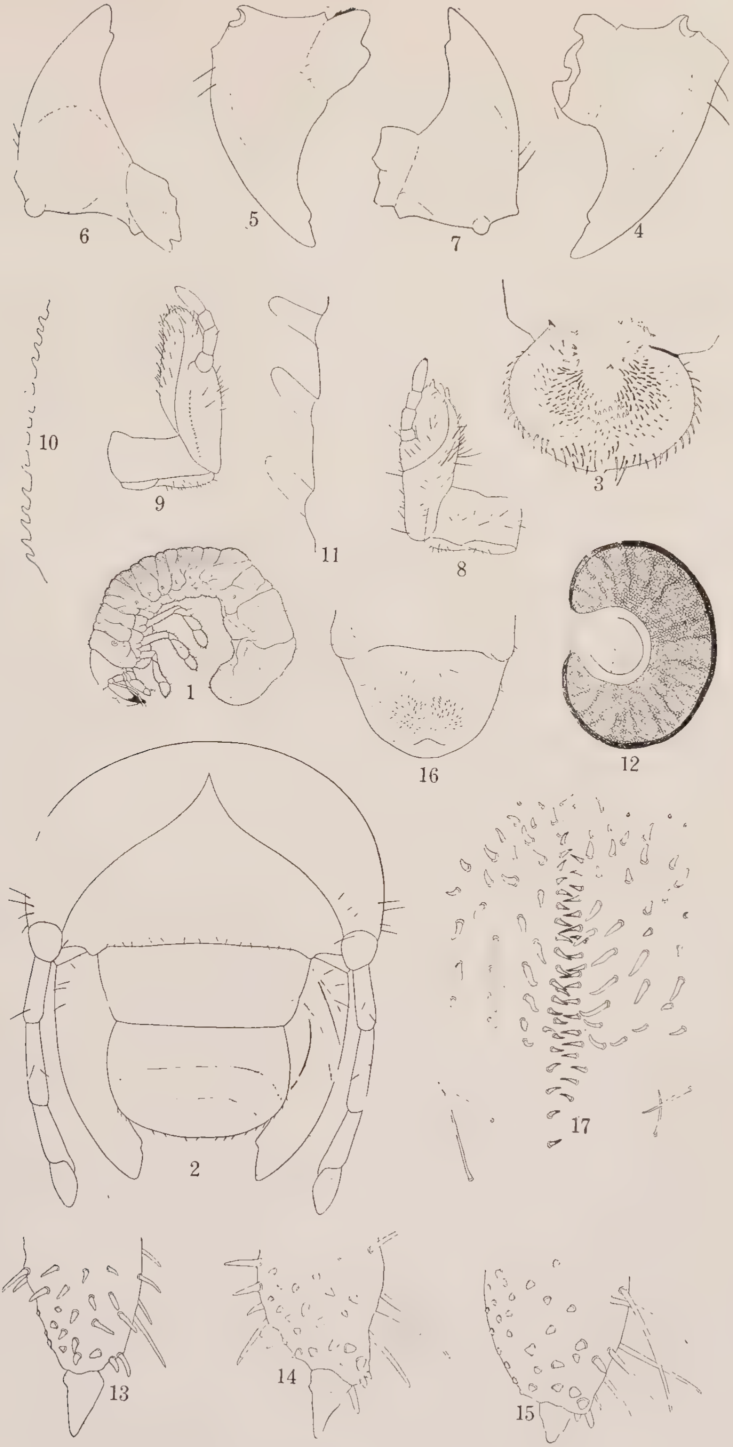

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PLATE 5

Stephanopholis philippinensis Brenske, second instar

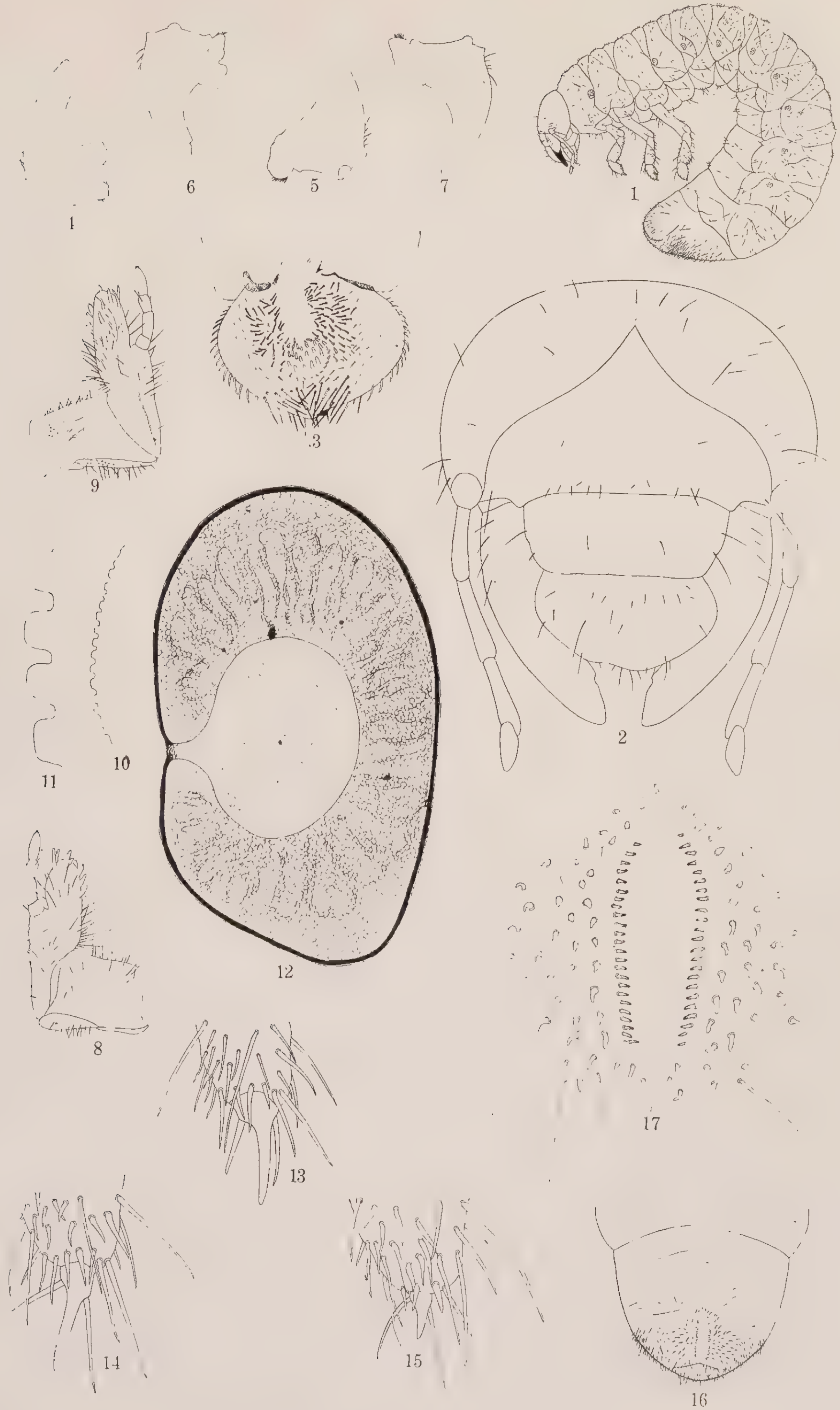
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PLATE 6

Holotrichia flachi Brenske

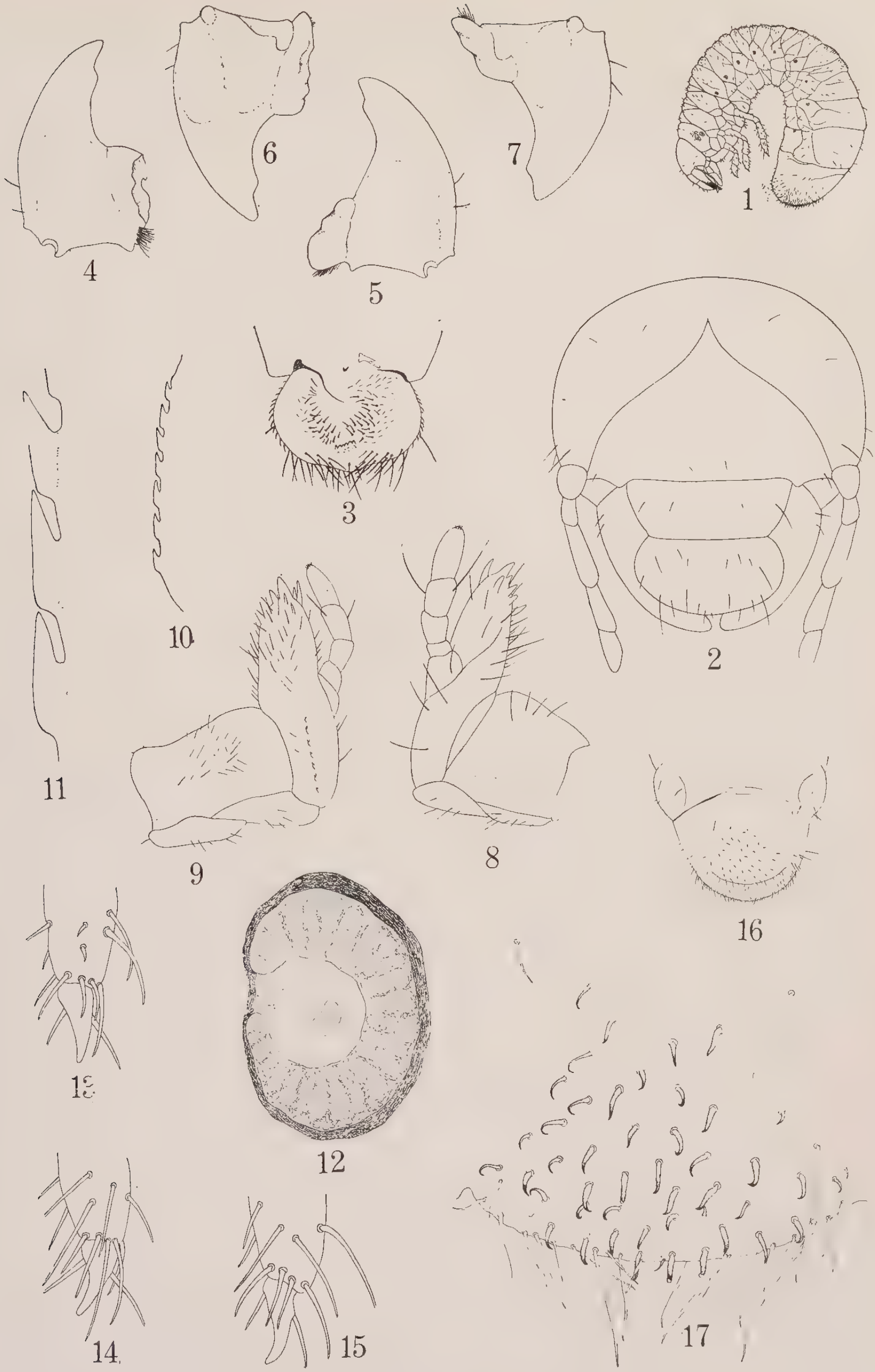
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PLATE 7
Autoserica nigrorubra Brenske

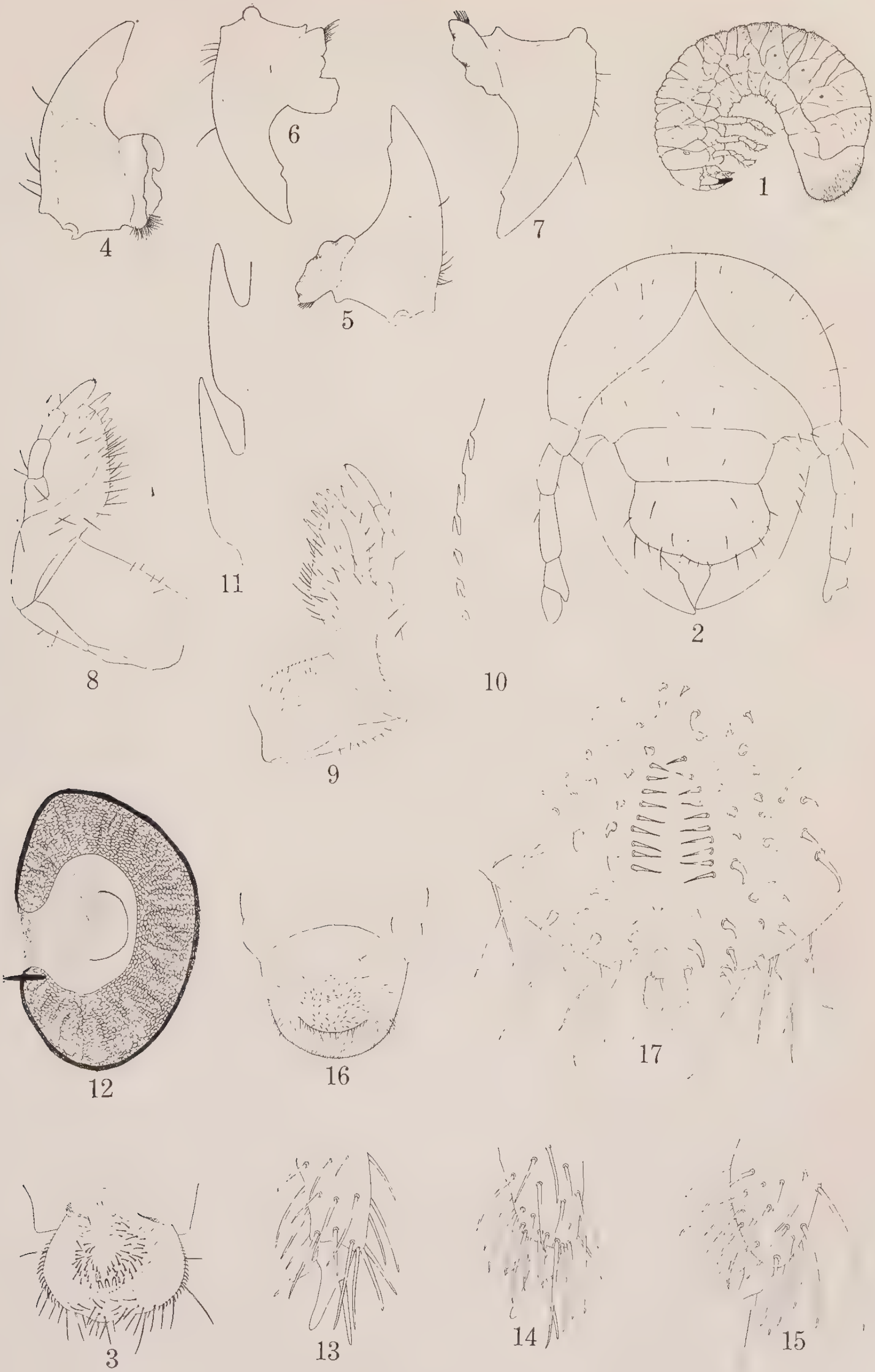
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PLATE 8
Anomala humeralis Burmeister

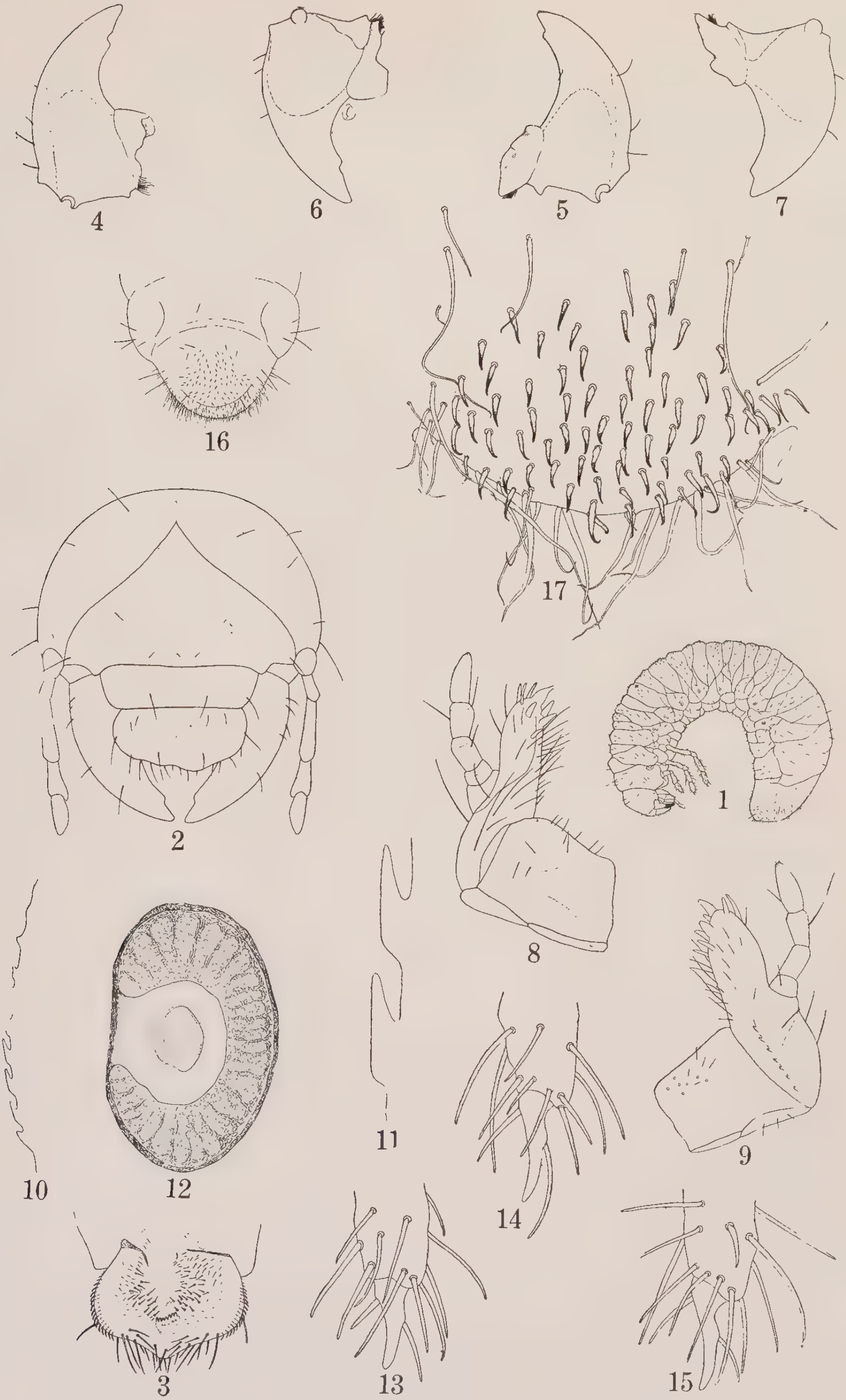
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PLATE 9
Adoretus luridus Blanchard

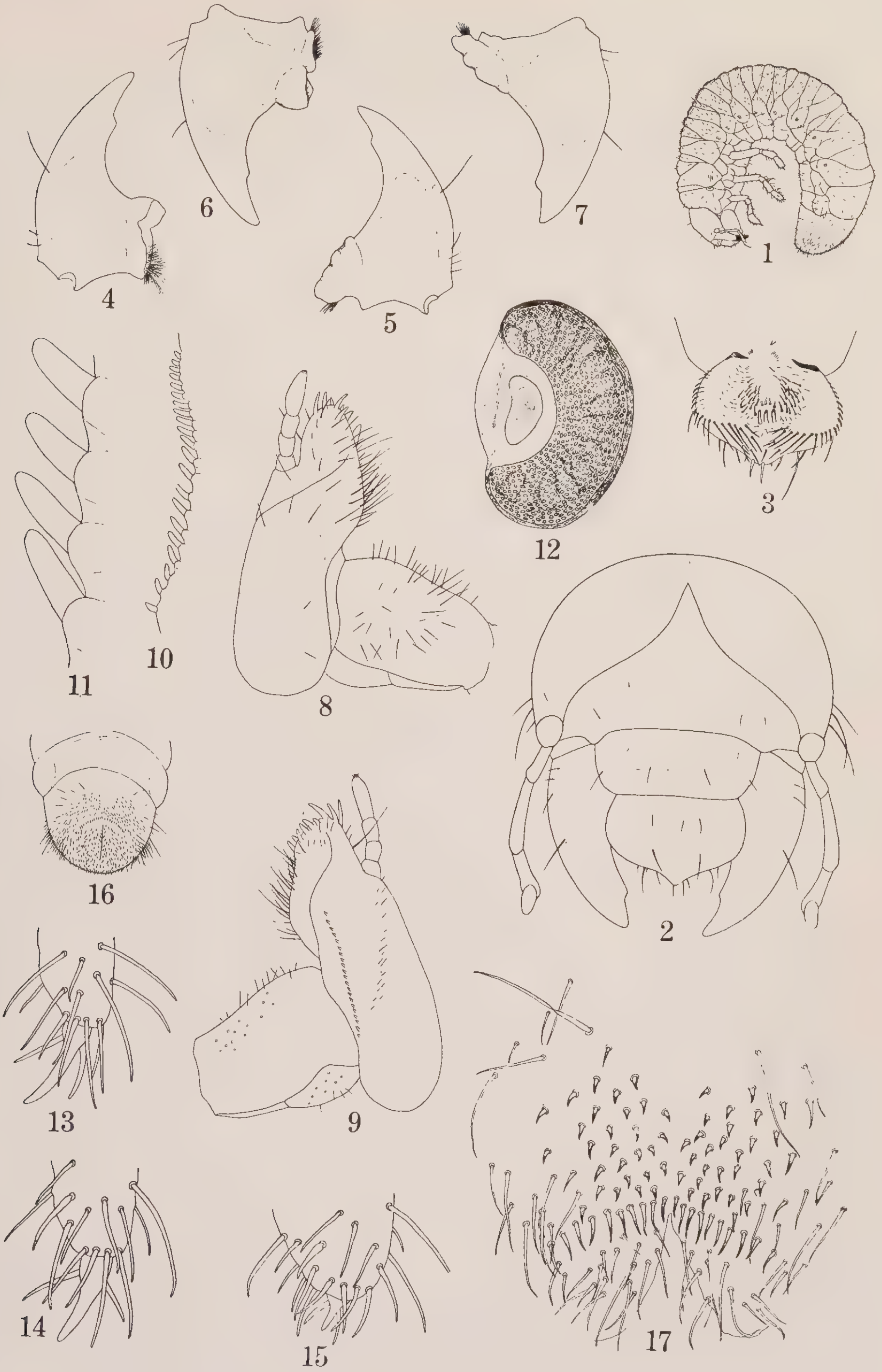
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Plate 10

Adoretus (Lepadoretus) ranunculus Burmeister

THE REPORT OF THE JOINT PREPARATORY COMMITTEE ON PHILIPPINE AFFAIRS AND PROPOSED AMENDMENTS TO THE ECONOMIC PROVISIONS OF THE INDEPENDENCE LAW[1]

José E. Velmonte
Of the Department of Agricultural Economics

WITH FIVE CHARTS

At this writing there is pending before Congress important economic legislation which, in the words of Vice-President Osmeña who heads an economic mission at Washington, is of an emergency character.[2] This bill aims primarily to bring some degree of relief to the so-called "borderline industries" which face destruction following the general application of export taxes on November 15, 1940, as provided by the Independence Act.[3] For nearly four months, from January to April, previous to this emergency bill, otherwise known as the Philippine economic adjustment bill, an omnibus Philippine bill designed to effectuate in toto the comprehensive recommendations of the Joint Preparatory Committee on Philippine Affairs[4] was pending before the Senate territories and insular affairs committee. Unfortunately, because of opposition to the comprehensive alteration of the provisions of the independence law both by members of the Senate committee and influential commodity lobbies, the omnibus bill was finally tabled and, hence, never reached the floor of Congress. For over two months, from May to July, the Philippine economic adjustment bill, or the so-called emergency bill, has been made a football of Congressional politics. This bill is a compromise measure designed to help certain Philippine industries, namely, coconut oil, cigars, scrap tobacco, pearl buttons, and embroidery from the ruinous effects of export taxes. The bill is non-political in nature and no attempt is being made in any way to legislate regarding United States—Philippine trade relations after independence on July 4, 1946.

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[1] The greater part of this paper originally entitled "An analysis of the report of the Joint Preparatory Committee on Philippine Affairs was read before the Los Baños Biological Club on February 24, 1939. General contribution from the College of Agriculture No. 685.

[2] When this paper was in press, the Philippine economic adjustment bill was finally approved by Congress and signed by the President on August 7, 1939.

[3] Otherwise known as the Tydings-McDuffie Act. Public No. 127 73d Congress (H. R. 8573) Approved, March 24, 1934.

[4] Unless otherwise specified in full, it is referred to henceforth as the Joint Committee.

In order to understand the fundamental basis of this pending economic legislation before Congress and of other remedial measures that in the future might have to be considered by that body in behalf of the Philippines, it would be necessary to analyze in brief the report of the Joint Preparatory Committee on Philippine Affairs.[5] Upon this report, the Philippines has placed its hope for relief from imminent economic hardships that will soon be felt under the provisions of the Independence Law.

A brief history of United States-Philippine trade relations

Sovereignty over the Philippines was ceded by Spain to the United States by virtue of the treaty of Paris proclaimed on April 11, 1899. From the very beginning, the American policy has been to enlarge Philippine autonomy with political independence as its final goal. On the other hand, increasingly stronger economic ties have been made to bind the Philippines with the United States. This is shown in the development of United States-Philippine trade relations.

For a brief period from August 13, 1898, to March 8, 1902, the trade between the two countries was on a non-preferential basis. The act of March 8, 1902, granted a 25 per cent tariff reduction on Philippine goods entering the United States without a corresponding preference for American goods entering the Philippines. The United States tariff act and the Philippine tariff act, both passed by Congress on August 5, 1909, inaugurated free trade relations between the two countries subject to certain quantitative limitations. Unlimited free trade was provided for in the United States tariff act of October 3, 1913, which struck out the limitations imposed by the previous law. For twenty-two years thereafter, the trade between the two countries has been on this unrestricted free basis.

The year 1934 marked the beginning of a period of restrictions. The Independence Act of March 24, 1934, while imposing no limitations on American goods entering the Philippines, placed restrictions upon the quantities of Philippine sugar, coconut oil, and cordage which may enter the United States free of duty. In addition, it required the imposition by the Philippines beginning November 15, 1940, of progressive export taxes upon Philippine products shipped to the United States. Finally, the law implies that after July 4, 1946, Philippine products will be subject to full duties under the American tariff. Other restrictions have since been imposed. The United States Sugar Acts of 1934 and 1937 placed an absolute limit upon the quantity of sugar that may be sent by the Philippines to the United States. The Revenue Act of 1934 and similar others that followed imposed an excise tax on coconut oil processed in the Philippines or in the United States of three cents per pound. Furthermore, the Sugar Act of 1937 provided for the imposition of a processing or excise tax of one-half cent per pound on Philippine sugar. The proceeds of these taxes, fortunately enough, are being remitted to the Philippine treasury.

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[5] Joint Preparatory Committee on Philippine Affairs. Report of May 20, 1938. 1: xii + 215p.; 2: vi + 664p.; 3 (Group 1): x + 1-724; 3 (Group 2): x + 725-1429. Washington: United States Government Printing Office.

The Independence Act

The economic provisions of the Independence Act may be summarized briefly as follows: Trade between the United States and the Philippines continues as heretofore on the free trade basis, subject, however, to limitations of duty-free quotas for sugar of 850,000 long tons, for coconut oil of 200,000 long tons, and for cordage of 3,000,000 pounds.

To help adjust industries dependent on the American market to a non-preferential status after independence, the law provides for the levy of export taxes during the last five-year period of the Commonwealth government. These taxes begin with 5 per cent of United States duties for the sixth year (Nov. 15, 1940—Nov. 15, 1941) of the Commonwealth government, increasing by 5 per cent annually so that by 1945 (and continuing to the inauguration of independence on July 4, 1946) a maximum of 25 per cent of the customs duties shall have been imposed as export taxes on Philippine products shipped to the United States. The proceeds of these taxes are to be solely used in the retirement of the Philippine bonded debt.

It is noteworthy, however, that no provision is made in the Independence Act restricting in any manner the entrance of American goods into the Philippines. Furthermore, while Congress has the right, which it recently exercised, to pass restrictive legislation with reference to Philippine exports to the United States, the Philippines has no legal power to restrict its imports of American goods by tariffs or quotas during the Commonwealth period.

The Joint Preparatory Committee on Philippine Affairs

Even before the passage of the Independence Act, Philippine leaders were not fully satisfied with many of its provisions, and in the resolution of acceptance (May 1, 1934) the Philippine Legislature noted that certain provisions of the law need further consideration. It was President Roosevelt's statement in his message to Congress recommending the passage of the act that gave assurance of future consideration of certain "imperfections or inequalities" that may be found in the provisions of the Independence Act.

In line with this expressed policy, on April 14, 1937, in consultation with the President of the Philippines, President Roosevelt formed the Joint Preparatory Committee on Philippine Affairs by appointing the American members, while the President of the Philippines appointed the Filipino members, to study the problems and to formulate recommendations looking toward the correction of any imperfections or inequalities in the Independence Act. The report was signed at Washington on May 20, 1938, and released to the public on Nov. 29, 1938.

The trend and character of United States-Philippine trade

American occupation has accelerated the development of Philippines' overseas trade (chart 1). In 1897, the year before the cession of the Philippines to the United States, the total trade was a little over ₱60,000,000. In 1900 it was ₱96,000,000; in 1910, ₱181,000,000; in 1920, ₱601,000,000; in 1930, ₱513,000,000; and in 1937, ₱552,000,000. The American share of this trade has increasingly become larger and larger. Of the total Philippine exports, the American share was 13 per cent in 1900; 42 per cent in 1910; 70 per cent in 1920; 79 per cent in 1930; and 82 per cent in 1937. Of the total Philippine imports, American goods were 9 per cent in 1900, 40 per cent in 1910, 62 per cent in 1920, 64 per cent in 1930, and 58 per cent in 1937. (Chart 1). These increases in trade and also in American participation have been attained coincident with the grant of preferential trade relations.

The United States market for Philippine products

The increasing dependence of Philippine products on the great American free market is evident from the figures presented above. This trend has tended to draw away Philippine staples from the various competitive markets of the world towards the more profitable protected American market (chart 2). Sugar, the premier export, is sold only to the United States. In 1937 it was worth ₱115,000,000 or 35 per cent of the total Philippine exports. Nearly all coconut oil and desiccated coconut are bought by the United States, whereas only about three-fourths of the copra represents the American share. The combined value of coconut exports for 1937 was ₱91,000,000 representing 30 per cent of all exports. Only about one-fourth of the abaca is sold to the United States; the remainder is taken by Japan and the United Kingdom. The value in 1937 was ₱43,000,000 accounting for about 12 per cent of the total exports. Normally, about one-half of the cordage shipments goes to the United States, although in 1937, of the nearly ₱3,000,000 of cordage, only 35 per cent represented the American share. Cigars represent about one-half

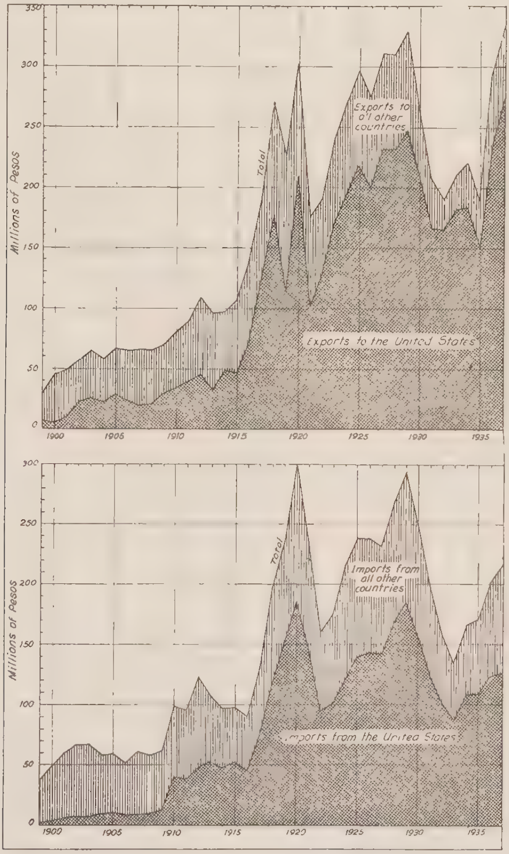

Chart 1.—Volume of Philippine overseas trade with all countries and the United States, 1900-1937.

of the tobacco exports of which about 90 per cent is purchased by the United States. Total tobacco exports for 1937 were valued at ₱10,000,000 or 3 per cent of all exports. Of this value, ₱6,000,000 were cigar exports. Practically all the embroidery export, which was valued at ₱7,000,000 in 1937, is sent to the United States. About one-fourth of the lumber shipments goes to the United States. Total lumber exports for 1937 were ₱7,800,000 of which 32 per cent was the American share. Other exports for which the United States provides a relatively large market are canned pineapples, chrome ore, hats, cutch, pearl buttons, and gums and resins.

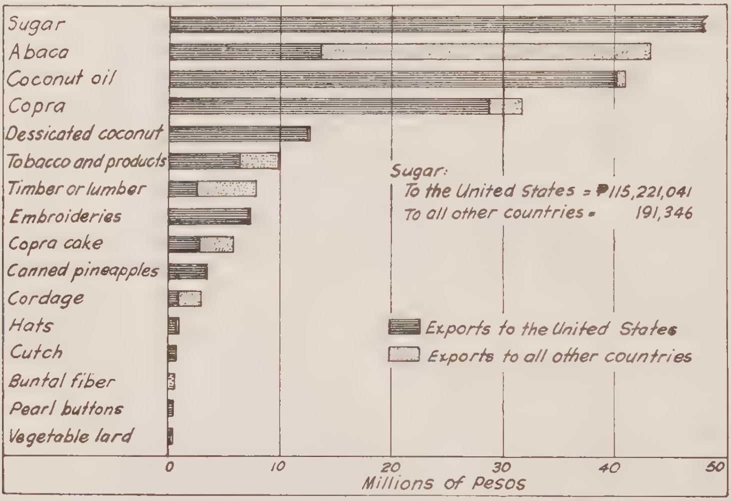

Chart. 2.—Principal Philippine exports showing the share of the United States, 1937.

The products listed above constituted in 1937 fully 96 per cent of the total value of Philippine exports to all countries. From the standpoint of the United States, however, its purchases from the Philippines in 1936 valued at over ₱202,000,000 represented only 4.2 per cent of her total imports. The Philippines ranked seventh in that year among United States suppliers. In the case of some products, however, United States purchases from the Philippines constituted a large proportion of her imports. Thus, on the basis of value, the Philippines supplied 99 per cent of coconut products, 80 per cent of tobacco manufactures, 87 per cent of sawed cabinet woods, 98 per cent of cotton embroidery, and 38 per cent of sugar.

The Philippine market for United States products

During the last decade, 1928-1937, the annual value of United States exports to the Philippines averaged ₱129,030,000 representing 63 per cent of the total value of Philippine imports. In 1937, imports from the United States amounted to ₱126,604,000 representing 58 per cent of the total from all countries (chart 3).

Iron and steel products ranked first in importance, representing 22 per cent of the total purchases from the United States, valued at more than ₱28,000,000. This value constituted about 73 per cent of all Philippine imports of iron and steel. Cotton goods ranked next, valued at more than ₱15,000,000, representing 44 per cent of the total amount imported. Mineral oil was third with ₱9,600,000 or 75 per cent; automobiles and parts placed fourth with ₱9,000,000, representing 99 per cent; tobacco products ranked next with ₱7,200,000 or 99 per cent. Electrical machinery, rubber and its manufactures, unprinted paper, chemicals and drugs, and wheat flour ranked next in the order of importance among Philippine purchases from the United States.

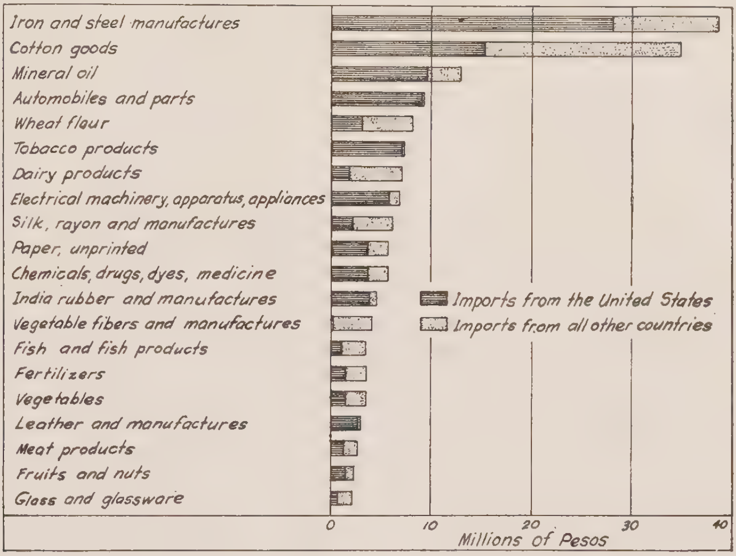

Chart 3.—Principal Philippine imports showing the share imported from the United States, 1937.

The Philippines stood ninth among the principal export markets of the United States in 1936, buying nearly ₱120,500,000 of products representing 2.5 per cent of total American exports. The Philippines ranked first in importance as market for the following American exports with individual values between one to seven million pesos: cigarettes, steel galvanized sheets, wheat flour, dairy products, explosives, sewing machines, toilet preparations, and educational textbooks. In addition, the Philippines as a market for American goods ranked second with values between two to thirteen million pesos each in the following: cotton manufactures, rubber and its manufactures, and fertilizers.

Anticipated effects of the provisions of the Independence Act on Philippine economy

The economic provisions of the Independence Act, principally, the graduated export taxes will not affect in the same degree all industries, the products of which enter the United States. In the first place, several commodities, like abaca, copra, and lumber are on the "free list" in the American tariff, that is, they are admitted duty-free from all countries. In the second place, a number of industries with dutiable products, notably sugar and cordage, will doubtless be able to continue exportations despite the imposition of export taxes. Finally, it is believed, certain Philippine industries will be forced to curtail drastically or to discontinue shipments to the United States upon the levy of export taxes, as coconut oil, cigars, scrap and filler tobacco, and pearl buttons. The analyses of the problems involved and the probable effects of the imposition of export taxes on individual commodities are briefly summarized in the following.

Sugar. The present duty on foreign sugar is 1.875 cents per pound. The Cuban rate is 20 per cent lower under a reciprocity treaty of 1902, or 1.5 cents. The United States granted a further reduction from 1.5 cents to 0.9 cent per pound in favor of Cuba by virtue of a trade agreement of August 24, 1934. This special reduction is to remain in effect as long as the quota system governing sugar shipments to the United States continues in operation.

Before the quota system was established, sugar prices in the United States approximated world prices plus the duty on Cuban sugar. Philippine sugar on a duty-free basis sold for the full American price and received, therefore, a premium equal to the Cuban tariff rate. Since the adoption of the quota system, United States sugar prices have not been definitely related to the world price. Up to the present time, this price has exceeded the world price not only by the Cuban duty, but also by more than the full duty. As long as the quota system prevails, Philippine producers will no doubt be able to sell in the United States market the quantity of preference sugar (850,000 long tons) fixed by the Independence Act. With the present level of prices, even the imposition of export taxes will enable Philippine producers to benefit from the duty-free privilege.

Should the quota system be abolished, American sugar prices would again resume a definite relationship with world prices. Assuming no change in the sugar duty, the Cuban tariff would return to 1.5 cents per pound, and Philippine sugar would continue to have a marked advantage over Cuban sugar. Even during the tenth year of the Commonwealth government, the export tax would only equal 0.46875 cents per pound (table 1). Considering transportation, the total of these costs for Cuba would be 1.63 cents as against 0.78 cent for the Philippines, or an advantage in favor of the Philippines of 0.85 cent per pound. On the basis of average sugar costs as reported by the U. S. Tariff Commission for the three crop years, 1929-1930, 1930-1931, and 1931-1932, delivered cost, duty or export tax paid, in New Work would be for the Philippines, 3.11 and Cuba, 3.31 cents per pound.

After independence, Cuba will have an advantage over the Philippines of 20 per cent preferential, as well as in lower transportation cost. In the absence of a quota system, Philippine producers will be obliged to have a cost of production low enough to enable them to sell at world prices. If on the other hand, a quota system is still in force, and if some allotment is made to Philippine sugar, then prevailing prices in the United States will determine shipments to that market. In the opinion of the Joint Committee, it is doubtful on the basis of present prices that an appreciable number of Philippine producers will be able to reduce their costs sufficiently to enable them to pay the full duty in 1946.

Coconut products. The Independence Act and the United States Revenue Acts of 1934, 1935, and 1936 will have profound effects on the exportation to the United States of copra, coconut oil, copra cake and meal, and desiccated coconut. Under the Independence Act, the duty-free quota for coconut oil is 200,000 long tons, an amount somewhat larger than normal exportation. All other coconut products are not similarly restricted. From Nov. 15, 1940, however, progressive export taxes will apply to coconut oil, copra cake and meal, and desiccated coconut (table 1). Copra being on the "free list" has never enjoyed any protection and it will not likely suffer from any adverse effects.

The coconut oil industry competes with a similar industry in the United States. About 50 per cent of the coconut oil consumed in the United States is produced by Philippine mills, the remainder being supplied by domestic mills using Philippine copra almost exclusively. The imposition of export taxes will affect seriously the coconut oil trade. Philippine and American mills obviously buy Philippine copra on the same price basis and any advantage local mills may have over United States mills must be found in the relatively small cost of crushing copra which is estimated to be less than one-half cent per pound. Philippine producers maintain that there is hardly any advantage; hence, the imposition of 0.1 cent export tax during the sixth year of the Commonwealth will prove crucial to the local oil industry, as the margin of profit at present is estimated to be from 1/8 to 1/10 cent per pound. By the seventh year of the Commonwealth, the export tax of 0.2 cent per pound will far exceed present profits and, therefore, will liquidate the business. The probable result, therefore, will be to transfer the crushing industry from the Philippines to the United States. This will mean also the loss of copra meal and cake as an export.

There is, however, a compensatory gain in that copra exports should increase by an amount approximately corresponding to the loss of coconut oil. Desiccated coconut will be subject to export taxes, the full duty at present being 3.5 cents per pound. United States imports in recent years are largely from the Philippines, representing about 97 per cent of the total. It is the belief that trade in this product will not be very seriously affected by export taxes since even in the tenth year of the Commonwealth with an export tax of 0.875 cent, the remaining tariff preference over the Ceylon product will still be over 2.6 cents. After independence, the effect is problematical; the belief is that it will be able to retain a large fraction of the American market despite the duty.

The U. S. Revenue Acts of 1934, 1935, and 1936 impose an excise tax on Philippine coconut oil, either processed in the Philippines or in the United States, of 3 cents per pound, and on foreign coconut oil of 5 cents. While there is a tax preference in favor of Philippine oil, many domestic oils which are competitive are tax exempt, and many of these oils when imported from foreign countries pay excise taxes not higher than 3 cents. Consequently, the effect of the excise on Philippine coconut oil will be to lower its competitive position in the American market. Domestic oils have increased in price, while Philippine coconut oil has been depressed in price. The situation becomes more critical because there have sprung up new competitors which are tax exempt and some also duty-free, as for example, babassu oil.

After independence, the imposition of the non-preferential rate of 5 cents would further weaken the competitive position of Philippine oil and would seriously injure the whole coconut industry. One ameliorating circumstance is that the Philippine government during the Commonwealth period is recipient of the proceeds of excise taxes which amount annually to about ₱34,000,000.

Abaca and cordage. Abaca like copra is on the "free list"; hence it faces no serious problem. Cordage, however, which is shipped under a quota of 6,000,000 pounds (under the Cordage Act of 1935, effective until May 1, 1941), will pay export taxes based on a duty of 2 cents per pound with an additional ad valorem rate of 15 per cent for diameters under three-fourths inches. The export tax will not cause any material reduction in the quantity exported, and while the application of the full duty after independence may reduce exports as well as profits, it seems unlikely that the duty will prove prohibitive.

Cigars. Philippine cigars will be subject to heavy export taxes in view of the very high duty on foreign cigars which amounts to $4.50 per pound plus 25 per cent ad valorem. The average price paid for Philippine cigars in the United States in 1936 was $15.14 per 1,000 including U. S. internal revenue tax of $2, or a net price to Philippine producers of $13.14. From this amount, they have to deduct cost of raw material, labor, overhead, packing and shipping charges, before they can have any profit. On the basis of present duty and wholesale prices, the export tax in the sixth year of the Commonwealth will amount to $4.20 leaving $8.94 to producers to cover costs and possible profit; in the eighth year, the tax will be $12.59 or almost equal to the selling price. It is obvious, therefore, that Philippine cigar exports will be abruptly curtailed by the imposition of export taxes. After independence, the duty will be prohibitive.

Anticipated effects of the provisions of the Independence Act on United States economy

The provisions of the Independence Act make it practically certain that the Philippines will decrease in importance as a market for American products and will be a less attractive field for investment by United States citizens. It has been shown that Philippine exports will decline with the levying of export taxes, and as a consequence, she will have to reduce her imports. The Philippines might transfer her purchases to other countries and thus reduce further her imports from the United States. Moreover, if the Philippines shapes her economy for greater self-sufficiency, imports will tend to decline further. The fall in United States-Philippine trade will mean, moreover, a lessened demand for services of American shipping, banks, and insurance companies.

There will be, however, some offsetting gains for the United States. After independence, duties will be assessed on Philippine goods, notably sugar; if it ceases to be sold in the United States, America will doubtless buy it elsewhere, thus creating new purchasing power which may be used to buy American goods. The United States treasury will no longer send the Philippine government excise tax collections. In spite of these gains, however, private American interests, will be injured in varying degree with the reduction in United States exports to the Philippines.

American participation in the cotton market has been declining largely because of strong Japanese competition. After independence, the tariff advantage will be lost, and imports of American cotton goods will further decline. Other adverse factors are the expected fall in the embroidery trade and the establishment of cotton mills in the Philippines. Imports of mineral oils now coming mostly from the United States will decline in profitableness if not in extent with the loss of the tariff advantage after independence. The withdrawal of the United States Army and Navy and the possibility of striking oil in the Philippines will prove contributing causes.

The profitable trade in American cigarettes will likely be lost almost entirely with the application of the prohibitive duty after independence. Dairy products, notably evaporated milk from the United States, are at present finding a profitable market in the Philippines, although the trend in recent years is toward a declining American participation. The application of duties after independence will likely cause a further decline in American dairy trade.

Recommendations of the Joint Committee on United States—Philippine trade

The Independence Act provides for the termination of trade preferences at the end of the Commonwealth period, that is, on July 4, 1946. Export taxes will reach a maximum of 25 per cent of duties during the last year, 1945, to July 4, 1946. Thereafter, export taxes will no longer be levied, but Philippine products will be subject to full United States duties. This change is so abrupt that it will be certain to affect adversely a number of Philippine export industries. In the case of the United States trade, the change from no restrictions of any kind during the Commonwealth period to full Philippine duties will be even more abrupt and United States interests will not have an adequate opportunity to make any adjustments.

In order to afford both American and Philippine interests a reasonable period to adjust themselves to the changed relationships, the Committee recommends that while the date of independence is to remain as provided for in the Independence Act on July 4, 1946, trade preferences should not be terminated but extended, although gradually eliminated, to the end of 1960. During the Commonwealth period, trade between the two countries is to remain on a duty-free basis. Unless excepted, Philippine products, notably sugar and cordage, shipped to the United States will pay export taxes, commencing with 5 per cent on January 1, 1941, to increase by annual accretions of 5 per cent, until on January 1, 1945, they shall have reached a maximum of 25 per cent. After July 4, 1946, both the United States and the Philippines are to assess 25 per cent of their duties on goods entering United States-Philippine trade, the

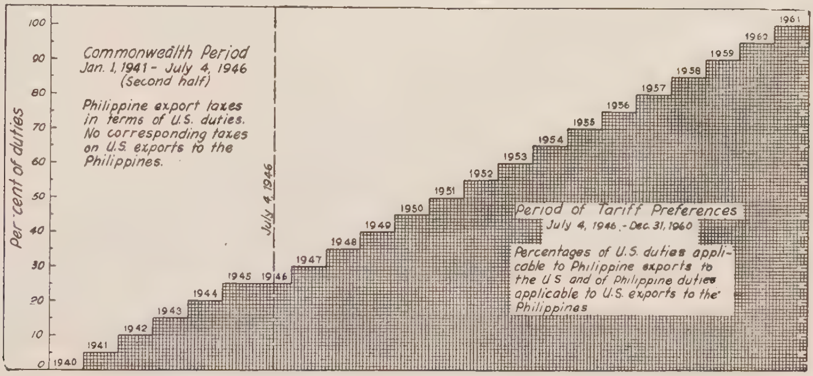

Chart 4. —Showing export taxes and United States duties on Philippine products as recommended by the Joint Preparatory Committee on Philippine Affairs. Applicable to all Philippine exports to the United States except those mentioned in chart 5. Applicable to:

Sugar with a quota of 850,000 long tons
Cordage with a quota of 6,000,000 lbs.
Embroideries (with certain deductions)

rate increasing progressively by 5 per cent on each succeeding January 1, until by January 1, 1961, full duties shall have been collected and all trade preferences terminated (chart 4).

The Joint Committee, however, has exempted from the export tax provision certain Philippine products on the ground that its imposition would quickly destroy such industries, namely, cigars, scrap tobacco, coconut oil, and pearl buttons. These products commencing with the calendar year, 1940, are allotted duty-free quotas declining progressively by 5 per cent annually, so that by January 1, 1961, no duty-free quotas will remain; consequently, all trade preferences will be terminated (chart 5).

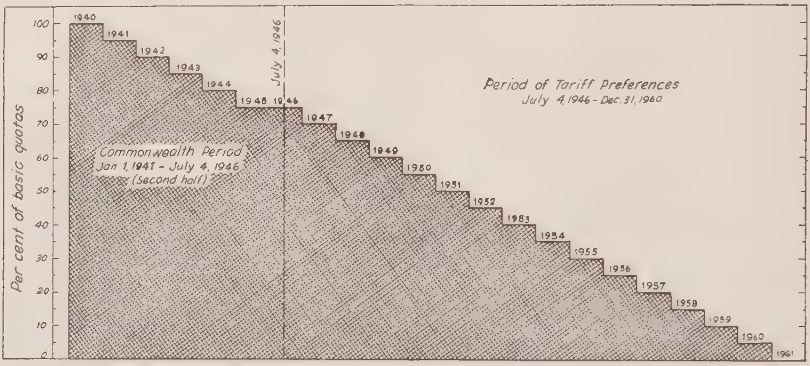

Chart 5.—Showing declining duty-free quotas as recommended by the Joint Preparatory Committee on Philippine Affairs. Applicable to:

	Basic quota for 1940
Cigars	200,000,000 units
Scrape tobacco	4,500,000 lbs.
Coconut oil	200,000 long tons
Pearl buttons	850,000 gross

[Also applicable to American cigarettes imported into the Philippines with a basic quota for 1947 of 2,100,000,000 units, and declining by 150,000,000 units annually (equal to 5 per cent of 3,000,000,000, the amount shipped to the Philippines in 1937)]

Special provisions referred especially to copra and abaca, which are to be bound free of duty, and the recommendation that the Philippines raises its tariff on evaporated milk, cotton textiles, and canned fish. Certain adjustments are provided for in the computation of export taxes and duties on embroideries when the textiles are of United States origin. Also after July 4, 1946, the excise tax on Philippine coconut oil will be no higher than the rate on palm oil or palm kernel oil. The trade relations between July 4, 1946, and December 31, 1960, should be incorporated in a treaty.

Finance

Financial problems of the Philippines are discussed under four topics, namely, revenues and expenditures, bonded indebtedness, currency, and, banking.

Annual revenues are sufficient to meet ordinary expenditures. The excise tax on coconut oil has provided since 1934 a source of extraordinary income averaging annually ₱34,000,000. The excise on sugar is estimated to yield an additional amount of ₱19,500.000 annually. Export taxes should yield for debt retirement purposes a total of ₱70,652,000 during the period, 1941-1946. After independence, these extraordinary incomes will cease, and it is probable that ordinary revenues will decline, while expenditures will most likely increase. The Joint Committee recommends that the Philippine government reserves the funds from excise taxes for purposes of economic adjustment. Certain principles have been laid down for spending this income: it should never be used as a substitute for ordinary revenues; expenditures should be orderly and carefully budgeted, avoiding hasty and uncoordinated disbursements to prevent undue inflation only to be followed by a severe deflation. Lastly, in anticipation of future financial requirements, a revision of the revenue system is necessary.

With the present method of providing for sinking funds, the net Philippine bonded debt on July 4, 1946, will be ₱42,560,000. The proceeds of export taxes estimated at over ₱70,000,000 will be more than sufficient to retire this debt.

It is recommended that the present currency system be maintained during the Commonwealth period. A study of the Philippine banking system is also recommended, although the Joint Committee does not believe in the need for establishing a central bank.

Economic adjustment

The adjustment of Philippine economy is necessary with the gradual elimination of trade preferences in the United States market. This is difficult, but with the extension of the period of trade preferences, ample natural resources, and sufficient funds, the main requirements are proper planning and execution. It is necessary to find replacements for those industries that will be adversely affected by the termination of trade preferences. It is also important to maintain purchasing power and adequate revenues by means of new or additional production for export and the production for domestic consumption of substitutes for those things now imported. The warning is made, however, that in fashioning a more self-sufficing economy, serious lowering of the standard of living should be avoided by an excessive and ill-advised policy of economic self-sufficiency. As a final objective, economic adjustment should help improve the efficiency of Philippine production with the government taking a leading part.

To finance a program of economic adjustment, it is recommended that the proceeds of excise taxes be reserved exclusively for it. Certain principles are set for guidance, as a careful budgeting over the entire period up to 1960, preference for projects requiring primarily capital expenditures with little maintenance expenses, preference for projects which will benefit large rather than small groups, and for those that will confer continuing rather than temporary benefit, and, lastly, for those which will promote crop diversification.

It is important that economic adjustment should be designed as an entirety under a single organization of competent technicians.[6] Suggested projects are indicated to point out in broad outlines the nature of a program of adjustment. Most important of these are: improvement of technical training by importing temporarily outstanding foreign technicians and adopting a long-range program to provide technical training for Filipinos by the improvement of educational facilities, scholarships, and sabbatical leaves for University professors; improvement of transportation facilities by a system of road construction in preference to railway projects, as well as the improvement of coastwise shipping; a program of conserving natural resources, such as forest, water, and soil; improvement of agriculture by means of a soil survey and mapping and a well equipped College of Agriculture for the development of agricultural science; a national agricultural experiment station system under the direction of the Department of Agriculture and Commerce; and national agricultural service stations for propagating and disseminating knowledge of improved agricultural practices among the farmers.

Other adjustment projects are along the improvement of agricultural credit, agricultural marketing and purchasing, tenancy, distribution of agricultural population by means of well planned resettlement projects, improvement of manufacturing, revision of the tariff, improvement of public revenue systems, and finally, improvement of health conditions.

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[6] The creation of the Philippine Economic Council in 1938 was presumably done in compliance with this recommendation.

Proposed Congressional economic adjustment legislation

In order to bring about a reasonable program of economic adjustment of Philippine economy as recommended in the report of the Joint Preparatory Committee on Philippine Affairs, it becomes necessary for Congress to pass legislation to amend the provisions of the Independence Act.

The omnibus Philippine bill. Less than a month after the report was released to the public on November 29, 1938, Senator Millard Tydings, co-author of the Independence Act and chairman of the Senate territories and insular affairs committee, introduced the administration economic adjustment bill on January 26, 1939. An identical bill was introduced in the House by Chairman Leo Kocialkowski of the House insular affairs committee. The bill proposes amendments to the Independence Act embodying in toto the recommendations of the Joint Preparatory Committee on Philippine Affairs. Summarized, the bill provides:

(*a*) For authorization of the President of the United States to negotiate an "executive agreement" (instead of a commercial treaty) with the Philippine Commonwealth President during the post-independence period from 1946 to 1960, providing for mutual trade preferences.

(*b*) For a common pool of the proceeds of coconut oil, copra, and sugar processing tax refunds, empowering the President of the United States to withhold refunds temporarily or permanently if he finds the Philippine government failing to use the funds for economic adjustment purposes.

(*c*) For all Philippine products entering the United States market unless otherwise excepted to be assessed export taxes at progressive rates provided for by the Independence Act, reaching a maximum of 25 per cent in 1945 and remaining at the same rate up to July 3, 1946. Then providing for the levy of 25 per cent of United States duties from July 4, 1946, to December 31, 1946, and increasing by five per cent on every succeeding January 1, until by January 1, 1961, 100 per cent or full duties shall have been assessed on Philippine products.

(*d*) For fixing copra and abaca on the free list.

(*e*) For establishing duty-free quotas not subject to export taxes for cigars, scrap tobacco, coconut oil, and pearl buttons. These quotas beginning with 1940 are to decline by five per cent annually until by January 1, 1961, such duty-free quotas shall have altogether disappeared.

(*f*) For establishing as heretofore an 850,000 long tons quota on sugar.

(*g*) For a cordage quota of 6,000,000 lbs. until 1961.

(*h*) For certain adjustments in the computation of duties on embroideries when the textiles are of United States origin.

(*i*) For requiring the Philippine government to hand over all export tax receipts to the United States treasury for retirement of all Philippine bonds.

(*j*) That the United States processing tax rate on coconut oil shall be no higher than the rate for palm oil or palm kernel oil.

(*k*) For establishing a duty-free quota on United States cigarettes exported to the Philippines of 2,100,000,000 in 1947, decreasing by 150,000,000 annually.

(*l*) That coconut oil and sugar tax refunds shall be budgeted and appropriated and accounted for separately for economic adjustment purposes.

(*m*) That the executive agreement may not be effectuated unless Philippine duties on canned fish, evaporated milk, and cotton textiles are raised.

(*n*) That if the President of the United States finds the Philippines has failed to make effective these foregoing provisions, the status of the entire legislation reverts to the Independence Act before amendment, and full duty would be established in 1946.

(*o*) That the amendments would be effective on January 1, 1940.

This bill for nearly four months from January to April, 1939, was under consideration by the Senate territories and insular affairs committee. Opposition from many quarters developed. Many members of the committee, doubtless shared by many in both houses of Congress, were apathetic to the reopening of the Philippine question. Influential commodity lobbies constituted powerful pressure groups bent on blocking any further concessions in behalf of Philippine products. Sensing defeat of the bill in the Senate committee, its supporters decided on April 18, 1939, to suspend action on the bill—to the dismay of the Philippine economic mission which had established quarters at Washington since January.

The Philippine economic adjustment bill. For almost a month after the tabling of the omnibus Philippine bill, the prospects were dark for an early consideration of any further legislation affecting Philippine economy by Congress. But because of persistent efforts by the Washington administration and also because of the undaunted spirit of the Philippine economic mission, a new Philippine economic adjustment bill was introduced in the Senate by Senator Tydings on May 10, 1939. Subsequently, a bill almost identical with that introduced in the Senate was presented in the House. This new legislation was not as comprehensive as the previous omnibus bill for it does not attempt to define United States-Philippine trade relations after 1946. The main objective is to give relief to certain Philippine industries which would be adversely affected by the imposition of export taxes after 1940. Many members of Congress are of the belief that United States-Philippine trade relations after independence should be left for future consideration. This postponement, it is also believed, would lessen opposition to the present bill by various interests opposed to the grant of any further trade concessions to Philippine producers. After many delays, the bill with certain amendments passed the Senate on May 31, 1939. The House bill suffered more delays but finally, on July 6, it was voted favorably out of the House committee on insular affairs only to be tabled by the House on July 17. As a result, the fate of the Philippine economic adjustment bill remained in doubt inasmuch as the bill that the House was considering was not exactly identical with the one that passed the Senate. Because of pressure of many domestic problems it looked as if no action could be taken on the bill this year when adjournment of Congress was near. Fortunately, on July 19, it was announced at Washington that the President and Congressional leaders had decided to include the Philippine bill among those that must be acted upon before adjournment sometime in August. In view of changes that have been made from time to time by both Houses of Congress in the provisions of the bill, it would be profitable to summarize the principal provisions of the bill in its present form now awaiting action by the House. The following are the salient provisions:

(*a*) Export taxes are to be assessed on Philippine products entering the United States beginning January 1, 1941, at five per cent of United States duties on such goods, increasing progressively by five per cent on every January 1, until it shall have reached a maximum of 25 per cent on January 1, 1945.

(*b*) It exempts from export taxes the following products and instead establishes declining duty-free quotas with original figures for 1940 as follows:

(1) Cigars	200,000,000 units
(2) Scrap tobacco	4,500,000 lbs.
(3) Coconut oil	200,000 long tons
(4) Pearl bottons	850,000 gross

These duty-free quotas beginning with January 1, 1940, diminish by five per cent on every succeeding January 1, (For the period from January 1, 1946-July 4, 1946, only one-half of the quotas set for 1945) until July 4, 1946. It also provides for certain deductions in the computation of export taxes on embroideries when the textiles are of United States origin. Exports in excess of quotas are subject to full duties.

(*c*) A sugar quota of 850,000 long tons to be allocated as provided for in the Independence Act.

(*d*) A cordage quota of 6,000,000 lbs. to be allocated by the Philippine government on the basis of shipments to the United States during the twelve months preceding the inauguration of the Commonwealth government.

(*e*) It requires the Commonwealth government to turn over all export tax receipts quarterly to the United States treasury for the retirement of Philippine bonds. A special trust account is to be set up with the treasurer of the United States to pay interest and principal of outstanding bonded indebtedness after July 4, 1946.

(*f*) It provides that at least two years before independence is granted, there shall be held a conference of representatives of the government of the United States and the government of the Commonwealth of the Philippines, the American members to consist of three United States Senators appointed by the President of the Senate, three United States representatives to be appointed by the Speaker of the House, and three members appointed by the President of the United States. On the part of the Philippine government, nine members are to be appointed by the President of the Philippines with the consent of the Commission on Appointments of the National Assembly. The purpose of the conference is to formulate recommendations as to future trade relations between the United States and the independent Philippine republic. It is expressly provided that no changes may be made in the procedure leading to independence as provided for in this act and in the Independence Law, or, in the date set for independence.

(*g*) It provides for the refund to the Philippine government of all proceeds of excise taxes on coconut oil and sugar and empowers the President to withhold refunds if he finds the Philippine government has failed to use them for economic adjustment purposes. Expenditures are to be budgeted, appropriated, and accounted for separately from other funds of the Philippine government.

(*h*) The proceeds from excise taxes on coconut oil after January 1, 1939, are free from previous restrictions in such a manner as, henceforth, to permit expenditures for providing facilities for better curing of copra and for bona fide production loans to Philippine copra producers. This is considered a great victory for coconut producers who have never been able heretofore to derive any direct benefit from the coconut excise taxes because of the conditions imposed in the refund of the proceeds of the tax to the Philippine government which prohibited its expenditure to subsidize the coconut industry.

While the prospects after 1946 seem dark for many industries dependent on the United States market, the immediate problem before the Philippine government is to secure Congressional legislation to give relief to the "borderline industries"—coconut oil, cigars, scrap tobacco, pearl buttons, and embroideries—which face destruction the moment export taxes become applicable; hence, the efforts of the Philippine economic mission to have Congress pass at least this compromise measure even if it carries out only in part the recommendations of the Joint Committee. The outlook towards the end of July is hopeful although the delay of over six months since January, is indicative of the opposition both by Congress and powerful commodity interests in the United States that has to be surmounted. One thing appears certain, however, that a longer time than the period of ten years granted by the Independence Act is necessary to effect a reasonable measure of adjustment of Philippine economy without imposing crushing hardships on the major industries. An additional period of fifteen years as recommended by the Joint Committee seems to be the minimum. Upon Congress, however, rests the sole right of modifying the provisions of the Independence Act.

SUMMARY

From the inception of the American administration, the policy has been towards enlarging Philippine autonomy with political indenpendence as the goal. In contrast to this political development, the economic ties binding the Philippines to the United States have become increasingly stronger. This is evident in the history and development of United States-Philippine trade relations.

The Independence Act restricted Philippine exports to the United States without similarly restricting the entrance of American goods into the Philippines. These restrictions applicable to Philippine exports were in the nature of duty-free quotas and the imposition of progressive export taxes. The period of transition from preferential trade relations to non-preferential status is so brief that it will not afford a reasonable opportunity for the industries to effect the needed adjustments. In view of these, the Joint Preparatory Committee on Philippine affairs was created to examine imperfections or inequalities of the Independence Act. Its findings show that of the principal Philippine exports, only sugar and cordage will have the possibility of withstanding the export taxes; whereas, cigars, coconut oil, pearl buttons, and embroideries will likely be destroyed by the tax. Copra, abaca, and lumber are on the "free list" and will suffer, therefore, no adverse effects. American trade in the Philippines will likewise suffer in proportion as Philippine exports will be curtailed.

In order to afford both Philippine and American interests a reasonable period of adjustment, the Committee recommends that while independence remains as provided for in the Independence Act on July 4, 1946, trade preferences should be extended, although gradually diminished, to December 31, 1960. The elimination of trade preferences will require an adjustment of Philippine industries with the idea of fashioning a more self-sufficing economy. With a planning organization financed by the proceeds of excise taxes, the principal projects of adjustment suggested are improvement of technical training, of agriculture, credit, agricultural marketing and purchasing, tenancy, resettlement, and tariff and tax revision.

Efforts to have Congress adopt the recommendations of the Joint Committee by amending the Independence Act have been made during the entire period from January to July, 1939, without much success. An omnibus Philippine bill designed to carry out in toto the recommendations of the Joint Committee failed of passage after

nearly four months (January to April) of consideration by Congress. A compromise measure of an emergency character has been before Congress since May with the object of giving relief at least to the "borderline industries" which face destruction following the imposition of export taxes towards the end of 1940. This bill adopts only in part the recommendations of the Joint Committee as it leaves for future consideration the question of United States-Philippine trade relations after 1946. While the prospects seem hopeful for its passage at this session, the long delay is indicative of the obstacles that have to be surmounted by the proponents of the bill and the Philippine economic mission that established quarters in Washington early this year.

TABLE 1

Showing export taxes and United States duties in cents per pound

PERIOD	SUGAR [a]	ABACA	EMBROIDERIES (Ad. Val.)	COPRA	COCONUT OIL	COPRA CAKE AND MEAL	DESICCATED COCONUT
First five years of the Commonwealth period (Nov. 15, 1935, to Nov. 15, 1940)	Free	Free	Free	Free	Free	Free	Free
Sixth year, export tax, 5% of U. S. duty (Nov. 15, 1940-Nov. 15, 1941)	0.09375 (₱0.26)	Free	3.75%	Free	0.1	0.015	0.175
Seventh year, export tax, 10% (Nov. 15, 1941-Nov. 15, 1942)	.1875 (₱0.52)	Free	7.50%	Free	.2	.030	.350
Eighth year, export tax, 15% (Nov. 15, 1942-Nov. 15, 1943)	.28125 (₱0.78)	Free	11.25%	Free	.3	.045	.525
Ninth year, export tax, 20% (Nov. 15, 1943-Nov. 15, 1944)	.375 (₱1.05)	Free	15.00%	Free	.4	.060	.700
Tenth year, export tax, 25% (Nov. 15, 1944-July 4, 1946)	.46875 (₱1.31)	Free	18.75%	Free	.5	.075	.875
After independence, July 4, 1946, full U. S. duties	1.875 (₱5.24)	Free	75%	Free	2.0	.300	3.500

[a] Figures in parentheses are equivalent rates of export taxes and U. S. duties in Philippine currency per picul.

COLLEGE AND ALUMNI NOTES

Acting United States High Commissioner, J. Weldon Jones, has accepted the invitation to be the guest speaker on Loyalty Day, October 10.

The class of 1929 will hold its tenth anniversary reunion on October 10, Loyalty Day, celebrating the thirtieth anniversary of the founding of the College. Members of the class desiring any information in connection with the celebration should communicate with Mr. Martin S. Celino, instructor in Plant Pathology and chairman of the committee for the reunion.

The subject of livestock improvement in the tropics drew wide interest in the Seventh International Congress of Genetics held in Edinburgh, Scotland, from August 23 to 30, 1939. Ten papers dealing with problems of production and improvement of farm animals in the tropics were presented by workers from widely scattered territories: South Africa, Gold Coast, Egypt, Southern United States, Brazil, Australia, India, and the Philippines. The Philippine contribution was a paper by Dr. Miguel Manresa of the College entitled: The influence of atmospheric temperature upon hemoglobin and other constituents of the blood of cattle.

Upon the request of the Department of Public Instruction, a series of monthly cultural lectures are being given by professors of the University of the Philippines to public school teachers of Manila at the Philippine Normal School Auditorium. Among those asked to give lectures are the following professors of the College: Prof. J. E. Velmonte on farm tenancy problems of rice production, August 26; Dr. N. B. Mendiola on what Filipino ornamental gardens and plants should be, December 9; and Dr. F. M. Sacay on objectives and methods of vocational education, March 9, 1940.

Friends of Professor Reginal H. King, formerly in charge of the course in sugar technology in the Department of Agricultural Chemistry, will be interested to know that he is now connected with the CCC of the United States Department of the Interior in connection with its work on vocational guidance, educational advisorship, and individual adjustment.

The following papers were read and discussed at the meeting of the Los Baños Biological Club on August 31, 1939:

Dr. V. C. Calma and Dr. L. G. Gonzalez. Studies on different containers for potting fruit plants.

Mr. J. P. Esguerra. The cost of production of corn silage at the College of Agriculture.

On August 29, several officials of the government of Thai (Siam) visited the College to observe its work. The party included Luang Ladakabad of the Ministry of Foreign Affairs, Thanod Navanukroh of the Civil Service Commission, Q. E. Richardson superintendent of Thai students in the Philippines, and Vaja Osohhananda, assistant superintendent.

A play, *Pierre Patelin* and the Kalinga Festival Dance were presented by the students of the College of Veterinary Science at the College of Agriculture on September 1, 1939. Mr. K. C. Mack of the Veterinary College was the director.

Social activities held recently on the College campus were the following:

August 12—Sunrise Club, reception and ball, Seniors' Social Garden.
August 19—Associated Women Students, benefit tea, Molawin Hall.
August 26—Ranchers Club, reception and ball, Seniors' Social Garden.
September 9 —Soil Tillers, reception and ball, Seniors' Social Garden.

Recent visitors to the College of Agriculture campus included the following:

Colegio de la Consolacion	August 3
Pacific Commercial Company, Service Station employees	August 10
Manila College of Pharmacy	August 14
Christian Endeavors	August 14
College of Law, Ateneo de Manila	August 14
U. P. Chinese Students' Association	August 14

PHILIPPINE LABOR ON THE ASCENDANT [1]

A social revolution in the traditional concept of labor is in progress in the Philippines. Since the new constitution which established the Commonwealth government on November 15, 1935, with its economic provisions giving the government more power in controlling private enterprise went into effect, an increasing tendency has been apparent in establishing a new doctrine with respect to labor in the country.

The old idea that labor is primarily a factor of production without regard for human rights has been the root cause of many abuses in the past, both in industry and agriculture. The problems of tenancy in the Philippines are in part traceable to this eighteenth century doctrine. The Philippine constitution, the new body of social legislation, and the expressed policies of the present chief executive have thrown this into the discard almost overnight.

The new principle is embodied in the Philippine constitution in these provisions: "The state shall afford protection to labor, especially to working women and minors, and shall regulate the relations between landowner and tenant, and between labor and capital in industry and agriculture." Likewise, "the promotion of social justice to insure the well being and economic security of the people should be the concern of the State." These constitutional provisions have found expression in a body of social legislation which because of limitations of space need only be mentioned in its most significant aspects.

Recognizing the increasing importance of the interests of workers, a Department of Labor was created in October, 1936. It is true of course that long before this a Bureau of Labor had been established as early as 1908 to look after the special interests of the laboring class but, like many other instrumentalities of government, it was a half-hearted attempt to solve problems of great magnitude. To safeguard the rights of workers, a Court of Industrial Relations was created in October, 1936, having jurisdiction over labor cases and clothed with ample powers. Its complex duties include the fix-

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[1] General contribution from the College of Agriculture No. 687.

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ing of minimum wages for laborers, and maximum rentals to be paid by tenants, enforcing compulsory arbitration in labor disputes, deciding labor cases, and in general, affording protection to labor." Since its organization, the court has already proved its great value by being instrumental in settling several important labor cases. On November, 1936, an act was approved which attempts to define and regulate legitimate labor organizations. While it gives the Department of Labor powers of supervision over bonafide organizations, it also prohibits landlords and employers from intimidating workers from joining labor organizations. The act, therefore, in no uncertain terms recognizes the right of labor to collective action and thus entrenches further its legal status. In order to protect adequately the rights of labor before the law, there are Public Defenders under the Department of Labor to defend indigent accused persons. Furthermore, to avoid delay in the administration of justice, an act was passed in June, 1938, giving the right of way in the courts to cases involving conflicts between labor and capital. While employers' liability in industrial accidents has been established for years by a law known as the Workmen's Compensation Act, the championing of the cause of labor by President Quezon has helped set the machinery of justice in such a way that delays and evasions by employers under the technicalities of the law have been done away with, resulting in forceful decisions of the court in favor of labor. Another victory of labor was the passage of an eight-hour law as early as 1933, but the principle was of limited applicability. It remained for the Commonwealth government to make all-inclusive its provisions by a series of amendments culminating in the approval of the present law making the length of the working day eight hours for all workers except piece workers, domestic help, and farm hands. Then on August, 1936, an important principle was embodied in Executive Orders Nos. 49 and 50, setting forth minimum wages and salaries of workers employed by the Insular government. This was incorporated in subsequent acts which further extended the principle by requiring private employers engaged in government projects to pay minimum wages prescribed by the government. While this law has no application to those in private employment, it is hoped that eventually employers may adopt similar policies. It may be said that in several labor disputes brought under the jurisdiction of the Court of Industrial Relations, the question of living wages was often raised. Finally, in order to discourage the reprehensible practice of delaying the payment of wages and salaries by employers or compelling workers to buy goods in employers' stores, a law penalizing these practices has recently been passed.

In the field of agriculture, the passage of the Philippine Share Tenancy law seven years ago was a great step towards improving the deplorable conditions of croppers. Owing, however, to imperfections, the law did not become operative until January, 1937. This act was intended to readjust lease contracts between landlords and tenants so as to remove many of the existing abuses. Recent amendments to this law are evidences of the special interest that the government has recently taken in the tenant's welfare as, for example: the acceptance of the testimony of the tenant as prima facie evidence on the terms of the contract in the absence of a written agreement or when the terms are set forth in a language not understood by him; the requirement of using standard weights and measures in all transactions between landlord and tenant; the prohibition imposed on the landlord against ejecting the tenant without the approval of the Department of Justice; and, finally, giving the Court of Industrial Relations jurisdiction over tenancy cases.

All this legislation, however enlightened, could not have sweepingly transformed the traditional concept of labor in the Philippines were it not for the driving energy and the zealous espousal by President Quezon of the cause of labor. To quote his own words, "the rights of labor are more precious than the rights to property because those of labor are human rights." His many public utterances along the same line as the foregoing, have given hope to the underprivileged, rescued labor from its condition of helplessness and exploitation, infused it with a new vigor and, in short, established in one sweep the doctrine that henceforth labor must be recognized as an equal partner of capital in industry and agriculture.

At this writing, under the sponsorship of the Secretary of Labor, the different labor unions are being organized into a National Congress of Labor, and the various organizations of farm workers, into a National Congress of Peasants. Steps are also made to unify these large bodies into one organization to promote their common interests. Obviously, everything has not been done, much is yet left undone, but labor in the Philippines has in the last four years achieved in the field of its rights a conquest which would have ordinarily taken it generations to accomplish.

The present trend, to a disinterested observer, has its disquieting consequences. This newly found power and strength of labor is a double-edged sword. It is an instrument of great force; like dynamite, in right hands it may prove useful in promoting the well-being of society, but in wrong hands, it can destroy labor itself. A responsible and intelligent leadership of labor, by all means, is urgently needed.

José E. Velmonte

The following presents a statistical comparison of the College of Agriculture in 1911 or two years after its founding, and in 1939, the year it celebrates its thirtieth anniversary:

Members of graduating class in 1911, 3; in 1939, 59.

Members of the alumni in 1911, 3; in 1939, 1229.

Members of the College Faculty in 1911, 18; in 1939, 78.

Members of the student body in 1911, 175; in 1939, 499, excluding 175 in the Rural High School, and 84 cross-registrants from the School of Forestry.

Number of coeds in 1911, 0; in 1939, 6.

Courses offered in 1911, 29; in 1939, 135.

Area of Campus and Farm in 1911, 74 hectares; in 1939, 397.5.

Number of College buildings in 1911, 5; in 1939, 97.

Volumes in the Library in 1911, 566; in 1939, 19,542.

College official transportation in 1911, bullock carts; in 1939, two trucks and one automobile.

Electric lights now provide the service before performed by candles, petroleum or coconut oil lamps.

Pails dipped in Molawin Creek and carried up its banks was the water supply system in 1911, now a fine system supplies water on the Campus.

There is now an Infirmary with a capacity of 26 beds and a full time director and physician, three trained nurses, a visiting College dentist, and a visiting surgeon.

There is now an ice supply, local and long distance telephone service, a first class post and telegraph office, and a guest house on the Campus.

FRESH COCONUT MEAT AS FEED FOR GROWING CHICKS[1]

F. M. FRONDA AND RODRIGO C. DOLES
Of the Department of Animal Husbandry

Fresh coconut meat is frequently fed to poultry, although no direct experimental study of it has been made. It seems desirable, therefore, to determine the feeding value of fresh coconut meat as poultry feed. If it should prove good, much of the coconut marketed as copra, some times at a loss, could be converted into chicken feed.

Using the rate of gain in weight as the measure of efficiency, Afalla (1938) reported that two parts of fresh coconut meat used in place of one part of corn, as a basic constituent of the ration, was 32 per cent more efficient as a feed for growing pigs than corn. When only one-half of the corn in the ration was replaced, the efficiency of the ration was only 35 per cent better than the standard ration. Under the conditions of the experiment and on the basis of feed required for a given unit of gain, Afalla found that 1.25 kgm. grated fresh coconut meat had a feed value approximately equal to 1 kgm. corn.

Mondoñedo and Realeza (1938) reported that for growing and fattening hogs cracked coconut meat had a feeding value equal to corn, and grated coconut was 6 per cent more efficient than corn, weight for weight. The same authors mentioned that for growing and fattening hogs, grated coconut meat, based on the cost of feed per kilogram gain in weight, was 85.4 per cent as efficient as corn, and ungrated coconut meat, 84.6 per cent as efficient when the cost of preparation was included.

In order to determine the feeding value for chicks of grated fresh coconut meat compared with that of corn and to find out whether or not it can replace corn, either partially or wholly in the ration, this study was made in the Department of Animal Husbandry from March, 1937, to March, 1938.

PLAN OF THE STUDY

Los Baños Cantonese chicks that were artificially hatched in a hot-water incubator from eggs laid by the flocks of the College were used in this study. Three sets of experiments were run and each set covered a period of twelve weeks. In the first set, 130 chicks were divided into five lots of 26 chicks each; in the second, 100 chicks were divided into five lots of 20 chicks each, and in the third, 125 chicks were divided into five lots of 25 chicks each.

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[1] Experiment Station contribution No. 1320.

These chicks were reared outdoors. For this purpose, a portable rearing house was used. The rations given to the different lots consisted of the following ingredients by weight:

INGREDIENTS	LOT I	LOT II	LOT III	LOT IV	LOT V
Rice bran	56.25	56.25	56.25	56.25	56.25
Corn meal	18.75	12.50	9.37	6.25	—
Fish meal	25.00	25.00	25.00	25.00	25.00
Grated fresh coconut meat	—	6.25	9.37	12.50	18.75
Nutritive ratio[a]	1:3.1	1:3.2	1:3.5	1:3.7	1:3.7

[a] Based on chemical analysis.

The following table shows the chemical analysis and composition of the two feeds as analyzed by the Department of Agricultural Chemistry.

	MOISTURE	ASH	PROTEIN	CRUDE FIBER	CARBOHYDRATES	FAT	CALORIES PER 100 GRAMS
	per cent	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*
Corn	13.53	1.57	7.47	1.63	74.55	1.25	341
Coconut meat	48.84	1.01	4.25	4.63	3.79	37.48	381

The average weight of the husked nuts used was 821 grams each. The water constituted about 24.85 per cent of the total weight of the nut; the shell, about 30.33 per cent; and the coconut meat, about 44.82 per cent. Thus, on the average, each nut yielded only about 368 grams of meat.

The basic feed, which consisted of rice bran, corn meal, and fish meal, and 1 per cent common table salt, was prepared weekly. Coconut meat was grated and mixed with the basic feed at each feeding time for the experimental lots. The birds in all the lots were fed three times a day in wooden feeding troughs which were kept open to them at all times during the day.

With the amount of the basic feed to be prepared and the amount of grated coconut meat to be used for one week known, the amount of fresh grated coconut meat to be added at each feeding time was computed. This method was employed at each feeding time for all the experimental lots.

The average prices per kilogram of the feeds used were based on the current prices in the local market when the experiment was conducted and were as follows:

Rice bran	₱0.038 per kgm.
Corn meal	₱0.045 " "
Fish meal	₱0.108 " "
Salt	₱0.011 " "

The price of the coconuts used in this experiment was ₱4.50 a hundred. Based on these prices, 100 kgm. of the rations given to the different lots cost:

Lot I	₱5.66
Lot II	₱6.14
Lot III	₱6.39
Lot IV	₱6.62
Lot V	₱7.11

Fresh drinking water was supplied to the chicks in bamboo watering troughs. This was available to the chicks throughout the day.

Records. The chicks, when taken down from the incubator, were leg-banded and their individual weights taken by means of an ordinary platform balance. They were weighed every week thereafter until the twelfth week. Records of the amount of feed consumed every week by the lots were also obtained. The mortality in each lot was likewise observed and recorded.

RESULTS AND DISCUSSION

Growth of the chicks. The weekly weight of the chicks at different ages was used as the criterion in determining the effect of the rations on their rate of growth. The average weights of the chicks from one day old up to twelve weeks in the different lots of the three series of experiments are shown in table 1.

By reference to table 1, it may be seen that there was not much difference in the initial weight of the chicks in the different lots except perhaps those in lot II which were significantly smaller than those in lot I. In the second week, however, the chicks in lot II were a trifle heavier than those in lot I, the check lot, although the difference was insignificant. When lots III, IV, and V were compared with lot I (control lot) in the second week, the rank of the different rations with regard to their efficiency in promoting growth of the chicks was shown: lot III and lot IV closely followed; lot II and lot V stood lowest. In this period the mean weight of the chicks in lot II was greater than that of lot I by 0.5 ± 1.41 grams; lots III, IV, and V were lighter than lot I by 2.0 ± 1.4 grams, 0.5 ± 1.52 grams, and 4.8 ± 1.42 grams, respectively.

At four weeks of age, the chicks in lot I were heavier than those in lot II. This difference, however, was not significant. Lots III and IV consistently maintained their former place as close third, although the lot III chicks were slightly heavier. The chicks in lot V were significantly smaller than the chicks in the check lot, lot I.

At eight weeks of age, the chicks in lot I were observed to be heavier than those in lot II, but the difference in their mean weight was not significant, this difference being only 5.1 ± 9.26 grams. The other lots followed their former trend in gain in weight. The lot II chicks, however, gained steadily more in weight until a significant difference of 59.7 ± 10.30 grams between lots I and II was observed when the chicks were ten weeks of age.

During the twelfth week, the lot II chicks were the heaviest, with a mean weight of 617.1 ± 12.06 grams, and those in lot V, the lightest, with a mean weight of only 545.5 ± 12.16 grams. Lots I, III, and V showed no appreciable differences in their mean weights. The average final weights of the chicks in all the lots in this study compare favorably with those reported by Eamilao (1938), who used in one of his lots a ration similar to the ration used in the control lot of the present study.

At 12 weeks, none of the lots showed any significant difference, lot II being only a little superior to lot I, as shown by the relatively heavier average weight of the chicks. This slight superiority of lot II over lot I was maintained only from the tenth week to the end of the experiment. Based on the mean weight of the chicks at this age, the different lots may be ranked as follows: lot II, first; lot I, second; lot III and lot IV, close thirds; and lot V, the last. These results were consistently maintained in all the three series of experiments.

It may be seen from this comparison that the ration containing 6.25 parts by weight of fresh grated coconut meat compared favorably with the check ration. As the grated coconut meat was increased to 9.37 and 18.75 parts of the ration, a corresponding decrease in efficiency of the ration to promote growth of the chicks resulted. Assuming that lot I, control lot, as 100 per cent efficient, it was found that lot II was 101.6 per cent; lot III, 95.3 per cent; lot IV, 96.0 per cent; while lot V was only 90.8 per cent efficient.

Feed consumption. The amount of feed consumed by each lot in the three sets of experiments is given in table 2, which shows that the average amount of feed consumed per chick during the brooding period was on the whole greater in those lots receiving additional fresh grated coconut meat in the ration. This seems to indicate that these rations were more palatable. It appears also that the greater the amount of coconut meat added to the ration, the more palatable the ration became.

Fronda and co-workers (1934) reported that the average feed consumption of chicks up to twelve weeks of age was 221.9 kgm. for 100 birds; Savella (1936), 344.4 kgm.; and Fronda and Agcanas, (1938) 283.0 kgm. The average amount of feed consumption reported in this study does not differ markedly with the results obtained by previous workers in this College.

Mortality. Table 3 shows the percentages of mortality in each series of experiments and the average percentage of mortality in each lot for the period of twelve weeks. It may be seen from this table that lot V, which had an average mortality of 41.05 ± 3.83 per cent, was the highest and lot II, which had an average mortality of only 14.46 ± 6.05 per cent, was the lowest. These results were consistent in all the three trials of the experiment. Eamilao (1938), using the same ration as that of the control lot, reported a higher mortality, 25.0 per cent. This was due perhaps to the fact that his chicks were reared indoors, where the chicks had very little access to a range. As the amount of fresh coconut meat added to the ration was increased there was an evident tendency, therefore, for the mortality of the chicks also to increase.

The high mortality experienced in the other three experimental lots, III, IV, and V, was perhaps due to the effect of the feed. Owing to the laxative nature of the coconut meat, most of the chicks died of diarrhoea in the earlier period of the experiment.

Returns above feed cost. The returns above feed cost given in table 4, which are based on tables 1, 2, and 3, were determined on the basis of 100 chicks at the start. The average final weights in each of the different lots (see table 1) at the close of the experiment were used as the basis in determining the total weights of the weanlings that may be produced from 100 chicks. At ₱0.60 a kilogram live weight, the value of the weanlings that may be produced was found to be highest, ₱31.83, in lot II, and lowest, ₱19.29, in lot V.

Likewise, the total feed consumption of the same weanlings was determined from the average consumption by each lot (see table 2). The total cost of the feed consumed by the weanlings was highest, ₱14.84, in lot V, and lowest, ₱10.84, in lot IV. The reason for this difference is that the chicks in lot V consumed the most feed.

From these figures, it may be seen that the returns above the cost of feeds, ₱19.79, was highest in lot II; lot I, the control lot, was second, ₱18.65; lots III, ₱11.63, and IV, ₱12.65, were close thirds; and lot V, ₱4.45, was lowest. The results obtained in the present study, therefore, show that of all the rations tested, that of lot II proved to be the most economical.

It should be noted that the coconuts used in this experiment cost, on an average, ₱4.50 per hundred. The average weight of the 268 husked nuts used was 0.821 kgm., of which 44.82 per cent or 0.368 kgm. was meat. Excluding cost of labor to prepare the feed, the coconut meat used in this study cost ₱0.125 a kilogram. When labor is included, although no actual data has been taken, the price per kilogram of coconut meat would certainly be increased. Therefore, at the price level of coconuts used in this study, 33.33 per cent of the corn meal in the ration for growing chicks may be substituted for coconut meat at a profit as long as the prices of rice bran, fish meal, and corn meal per kilogram remain low.

The price of coconuts, however, is also as variable as that of the other ingredients used. With the price of these other ingredients in the ration remaining the same and that of coconut variable, 100 nuts would have to cost ₱1.90 for lot III, ₱1.70 for lot IV, and ₱0.23 for lot V to make the rations as economical as that of the control lot, lot I. Assuming that coconuts cost ₱1.20 a hundred, it appears that substituting 33.33, 50.00, and 66.66 per cent of the corn meal in the ration as in the rations used in lots II, III and IV, respectively, will bring about a profit.

Other observations. In the early stage of the experiment the chicks in all the experimental lots seemed not to relish the coconut meat. Later, however, they began to like it so well that they picked it out first. In all cases, the chicks consumed the coconut faster than the other ingredients although this was well mixed in the ration.

It was observed that the chicks in lots I, II, and III feathered earlier than those in the other lots. The chicks in these lots were fully feathered at the age of seven or eight weeks. The chicks in lots IV and V were the slowest to feather. These chicks were not fully feathered until they were about ten weeks of age. It is interesting to note, however, that the feathers of the chicks in the lots fed with coconut meat were fine, glossy, and smooth in appearance. This may be attributed to the oil contained in the coconut meat included in the rations of these birds.

Diarrhoea seemed to be the main cause of death among the chicks eating fresh grated coconut meat.

SUMMARY AND CONCLUSIONS

1. Of the different rations studied, that of lot II, proved to be the best, both in economy of feeds and in the lower rate of mortality of the birds.

2. As the amount of fresh grated coconut meat was increased to 9.375 per cent of the ration the mortality of the chicks also increased.

3. With the ration of the control lot, lot I, taken as 100 per cent, it was found that the efficiency of the other rations in promoting growth of the chicks was as follows: lot II, 101.6 per cent; lot III, 95.3 per cent; lot IV, 96.0 per cent; and lot V, 90.8 per cent.

4. The average feed consumption per chick for the whole brooding period of twelve weeks was: 2.49 kgm. for lot I, 2.28 kgm. for lot II, 2.77 kgm. for lot III, 241 kgm. for lot IV, and 3.54 kgm. for lot V.

5. There were no significant differences in the average final weights of the birds at the end of the brooding period except those of lot V which were significantly lower than those of the control lot, lot I.

6. The calculated return above feed cost was highest, ₱19.79, in lot II, followed by ₱18.63 in lot I (control lot). Lots III and IV had a return of ₱11.63 and ₱12.65, respectively. Lot V gave the lowest return, ₱4.45, above the cost of feeds.

7. Even at the price of ₱4.50 per hundred nuts in this study, they may be used profitably as a substitute for 33.33 per cent of the corn meal in the ration.

8. To be as profitable as the check lot (lot I), with rice bran costing ₱0.038 a kilogram, corn meal at ₱0.045, and fish meal at ₱0.108, the price of coconut per hundred should be ₱1.90 if 50 per cent of the corn meal is replaced with coconut meat, as in lot III;

₱1.70 if 66.66 per cent of the corn meal is replaced with coconut meat, as in lot IV; and ₱0.23 if the whole amount of corn meal in the ration is to be substituted for coconut meat, as in lot V.

9. Feathering was earliest in the lots where the least coconut meat was fed. The coconut meat in the ration imparted a smooth, glossy appearance to the feathers of the birds.

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TABLE 1

The weekly mean weights of the chicks in the different lots for twelve weeks

AGE	LOT I		LOT II		LOT III		LOT IV		LOT V	
	No. of chicks	Mean weights	No. of chicks	Mean weights	No. of chicks	Mean weights	No. of chicks	Mean weights	No. of chicks	Mean weights
		grams		*grams*		*grams*		*grams*		*grams*
1 day	71	28.6 ± 0.24	71	24.9 ± 0.23	71	26.3 ± 0.21	71	25.8 ± 0.25	71	26.2 ± 0.29
1 week	67	38.6 ± 0.55	69	37.8 ± 0.63	65	38.6 ± 0.51	71	39.7 ± 0.53	63	37.3 ± 0.46
2 weeks	65	55.1 ± 0.86	69	56.0 ± 0.92	59	53.1 ± 0.87	68	54.6 ± 0.99	62	50.3 ± 0.84
3 "	64	76.5 ± 1.15	68	72.2 ± 1.51	58	70.5 ± 1.14	67	71.8 ± 1.29	56	65.9 ± 1.33
4 "	62	105.6 ± 1.48	65	100.9 ± 1.77	56	95.3 ± 2.13	65	92.6 ± 2.06	43	87.7 ± 2.58
5 "	61	135.9 ± 1.91	64	131.3 ± 2.25	52	121.5 ± 2.00	61	119.4 ± 3.41	37	114.6 ± 2.43
6 "	60	177.7 ± 2.61	63	161.4 ± 2.42	51	143.7 ± 2.60	54	150.5 ± 2.70	34	138.5 ± 2.80
7 "	60	249.5 ± 2.64	63	244.5 ± 4.94	51	220.0 ± 5.33	54	231.0 ± 6.16	34	207.5 ± 5.60
8 "	60	315.7 ± 6.01	63	310.6 ± 7.05	50	289.3 ± 7.35	52	295.3 ± 7.66	33	267.4 ± 8.02
9 "	60	399.6 ± 6.58	62	398.2 ± 7.72	49	370.5 ± 7.75	49	371.9 ± 10.08	33	338.7 ± 8.13
10 "	60	450.1 ± 7.20	61	509.7 ± 7.37	49	437.7 ± 9.10	48	430.5 ± 11.66	32	408.9 ± 8.37
11 "	60	536.9 ± 8.37	61	550.4 ± 9.80	49	508.6 ± 10.38	48	504.9 ± 13.30	32	478.4 ± 9.96
12 "	60	600.5 ± 9.98	61	617.1 ± 12.06	49	572.6 ± 12.00	48	576.5 ± 13.89	32	545.5 ± 12.16

TABLE 2

The amount of feed consumed per chick in each lot for the period of twelve weeks

LOT NUMBER	SET NUMBER 1	SET NUMBER 2	SET NUMBER 3	AVERAGE
	kgm.	*kgm.*	*kgm.*	*kgm.*
I	2.56	2.28	2.62	2.49 ± 0.121
II	2.06	2.15	2.62	2.28 ± 0.203
III	2.93	2.49	2.91	2.77 ± 0.167
IV	2.16	2.23	2.84	2.41 ± 0.249
V	2.78	2.85	4.99	3.54 ± 1.193

TABLE 3

Percentage of mortality of the chicks for the period of twelve weeks

LOT NUMBER	SET NUMBER 1	SET NUMBER 2	SET NUMBER 3	AVERAGE
	per cent	*per cent*	*per cent*	*per cent*
I	15.38	15.00	16.00	15.46 ± 0.339
II	15.38	20.00	8.00	14.46 ± 6.052
III	34.61	30.00	28.00	30.87 ± 5.348
IV	38.46	30.00	28.00	32.15 ± 6.584
V	46.15	45.00	32.00	41.05 ± 3.833

TABLE 4

Calculated returns above feed costs in the different lots on the basis of 100 birds at the start

LOT NUMBER	I	II	III	IV	V
Initial number of birds at the beginning of the experiment	100.00	100.00	100.00	100.00	100.00
Number of birds at the end of the experiment	85.00	86.00	70.00	68.00	59.00
Total feed consumed by the lot in kilograms	211.65	196.08	193.90	163.88	208.46
Cost of feed per 100 kilograms in pesos	5.66	6.14	6.39	6.62	7.11
Total feed consumed by the lot in pesos	11.97	12.04	12.39	10.84	14.84
Total weight of birds in kilograms	51.00	53.05	40.04	39.16	32.15
Cost of birds @ ₱0.60 per kilogram[a] in pesos	30.60	31.83	24.02	23.49	19.29
Returns above feed costs in each lot in pesos	18.63	19.79	11.63	12.65	4.45

[a] Table fowls sell at ₱0.60 per kgm. live weight.

FARM COSTS AND PRACTICES OF A TWENTY-HECTARE COCONUT PLANTATION IN LAGUNA PROVINCE [1]

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WITH ONE CHART

This paper describes the practices and analyzes the costs on a twenty-hectare coconut farm from records which have been regularly kept. The study covers a period of nearly ten years, 1928 to 1937. The entries in the owner's book were very simple. The description of items under each date was found on the left-hand side, and opposite each item, on the right-hand side of the page, was the amount spent or received, as the case might be, for the item. At the end of each year the total expenses for each group of items, such as transportation of labor and materials, labor, supervision and inspection, etc., were summed up to show the total cash expenses for operating the farm during the year. The total amounts received from the sale of products, such as coconuts, bananas, firewood, and livestock, as well as other values received, were also summed up to show the total cash received from the operation of the farm. The difference between the amount received and expenses showed more or less how the farm business had stood during the year. An inventory of the farm property was also shown at the end of each year.

The owner of this farm is the first coconut planter in the provinces of Laguna and Tayabas who was willing to show his records to the writer for analysis. This paper was written, therefore, in the hope that the description of the practices and the analysis of the costs of this farm might serve as an encouragement and guide to those farmers who have not as yet adopted the practice and appreciated the value of keeping farm records.

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[1] Experiment Station contribution No. 1321. The writer is indebted to the owner of the farm for his kindness and generosity in giving him access to his farm records and furnishing him other information concerning the property. Without the aid of this landowner, whose name for obvious reasons is omitted here, this study could not have been accomplished.

Location and organization of the farm

The Imuc farm is located along the west side of the provincial highway between the towns of Calauang and San Pablo in the province of Laguna. It has a total area of 19.9064 hectares. The farm was acquired by its present owner by purchase between November, 1928, and July, 1930, the largest portion of it, 14.3335 hectares, having been bought by him in November, 1928; another portion, 1.2819 hectares, in March, 1929; and a third portion, 4.2910 hectares, in July, 1930. The total purchase price of the farm was ₱18,250.00, an average of ₱916.08 a hectare.

The farm was divided into four lots. The lots were assigned to tenants who were responsible to the owner for the care of the crops within the areas assigned to them.

The main crop was coconut, but there were banana trees between the coconut trees and along the borders of the coconut plantation. Lanzones seedlings had also been planted between the coconut trees since the farm was acquired by its present owner. Firewood was cut from time to time from the underbrush on the plantation and offered for sale. A few head of cattle were allowed to graze under the coconut trees. These animals were under the care of one of the tenants.

The supervision and management of the farm was undertaken by the owner through the help of a paid overseer. The owner, however, made regular inspections of the farm.

Production of crops and practices on the farm

Harvest and sale of coconuts.—Ripe coconuts were harvested from this farm at the end of every two months. There were, therefore, six harvesting periods during the year. Each tenant in the first years of the period under review hired laborers to harvest the coconuts from the trees on his holding. The present practice is to sell the coconuts on the trees; the buyers hiring laborers to harvest the nuts. The representative of the owner (the overseer) supervised the harvesting of the crop. He obtained information from the prospective buyers of the coconuts regarding the prices they were willing to offer for the product. This information was given to the landlord who made the final decision. During the period from 1929 to 1937, records of the farm indicate that most of the coconuts sold during that period were purchased by the Franklin Baker Company at San Pablo, Laguna. This company buys coconuts for the manufacture of desiccated coconut products.

The tenants received one-third of the proceeds of the sale of coconuts produced from their respective holdings, when expenses of harvesting and marketing were borne by them; they received one-fourth of these proceeds when such expenses were borne by the buyer. The tenants received their shares of the proceeds of the sale of coconuts as soon as the landlord obtained the payment of this product from the buyers. The overseer, accompanied by the trusted tenant, usually went to the buyer and received the money for the landlord.

Production and sale of minor crops.—The tenants harvested and sold mature bananas from their holdings from time to time. They were not supervised in doing this work, but they turned over to the landlord the money they received whenever they made a sale. The tenants received one-third of the amount received from the sale of bananas up to May, 1934. Thereafter, they received one-half of this amount.

Firewood gathered from time to time by the tenants from the underbrush on the plantation was sold and the money received from such sale turned over to the landlord. The tenants received one-half of the proceeds from the sale of this minor product. As in the case of bananas, the tenants were not supervised in this work.

Cattle were not sold regularly every year. This was perhaps because the animals had to be given time to develop to a size which made them profitable for sale. Moreover, an opportune moment had to be awaited when the buyer offering the best terms appeared. Keeping the animals on the plantation did not incur much, if any, additional cost. In fact, the animals helped keep the plantation clean by grazing under the coconut trees. The tenant who took care of the cattle on the farm received one-third of the proceeds of the sale of the animals. This tenant, the records indicate, appeared to be the most trusted and most efficient among the tenants of the farm.

General treatment of tenants and laborers on the farm.—The records of the farm indicate that the landlord treated his tenants as real partners in the business of farming. The tenants shared in any increase or decrease in the income from the sale of the crops. They had complete freedom to exercise their individual initiatives. Those of them who showed special interest in the care and improvement of their holdings were properly rewarded by the landlord. The records show, for example, that the tenants had been paid sums of money as "gratuity" for good harvest, "premium" for cleanliness of holdings, etc.

The tenants were also paid regular daily wages for any work that they did for the landlord which took their time away from their holdings. For example, tenants received wages and transportation expenses for bringing money received from sales of crops to the house of the landlord, for reporting price offers of prospective buyers of coconuts or cattle, etc.

Extra labor was hired by the landlord whenever improvements were needed on the farm, because the tenants were not responsible even on their own holdings for general improvements, such as building of fences, planting lanzones seedlings, planting bananas, replanting vacant coconut hills, etc. Laborers employed for this work were paid a minimum daily wage of ₱1.20 each. The minimum wage paid to laborers of this farm was slightly higher than the average daily wage (₱1.19 in 1925) of unskilled agricultural labor in Laguna during the pre-depression years, and was about 63 per cent higher than the average wage (₱0.74 in 1930) for the same type of labor during the depression years. When the tenants of this farm worked for the landlord outside of their time on their own holdings, they enjoyed the same rate of wages as that which was paid to the extra laborers hired to make improvements on the farm.

The overseer received a daily wage of ₱2.00 from November, 1928, to April, 1934. The poor income obtained from the farm on account of the depression forced a reduction of this wage to ₱1.70 from March, 1934, to August, 1936. It was restored to ₱2.00 during the rest of 1936 and, in 1937, the overseer was given ₱1.50 a day plus 1 per cent of the gross sales of coconuts. This last arrangement, according to the records, netted the overseer a daily wage of more than ₱2.00. In addition to his daily wage, the overseer was given his transportation expenses from his home to the farm and return.

If the stability of tenure of the tenants, as well as that of the overseer, is an indication of satisfaction on the part of these people with the treatment they received from their landlord or employer, then, it may be said that the arrangement between the tenants and employees of this farm with their landlord or employer was entirely satisfactory to all parties concerned. The records show that the same tenants of the farm in 1928 worked there continuously during the period from 1928 to 1937. And there was no indication that they had any intention of leaving the farm after 1937. The same thing was true with the overseer. The overseer of the farm in 1928 was the same person mentioned in the records every year during the period under review, 1928-1937. The fact that these people stayed continuously for about ten years under the owner of this farm is evidence that they were satisfied with the treatment that they received from this landowner.

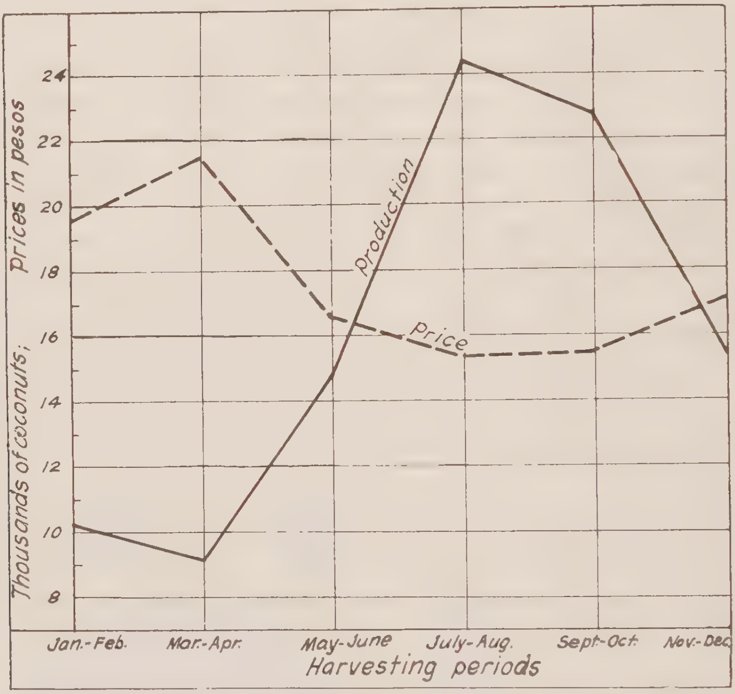

Chart 1.—Showing relation of price to quantity of coconuts produced in each of the harvesting periods in the year. Figures used are averages for the period from 1929 to 1937 (table 4).

Coconuts produced. Table 1 shows the quantity of coconuts harvested and the price received from them per thousand during each of the six harvesting periods in the years from 1929 to 1937. The number of coconut trees bearing and the average yield of each bearing tree are also shown in this table. In 1929, there were 1,216 coconut trees bearing. By 1935, this number increased to 2,150 and remained at that figure during 1936 and 1937. The total number of coconuts produced per year varied from 28,270 in 1931, the poorest year, to 148,620 in 1935, the most productive year. The average annual price per 1,000 coconuts varied from ₱5.73 in 1934, the worst year of the depression in the Philippines as far as coconut prices were concerned, to ₱30.91 in 1929. The average yield of each coconut-bearing tree varied from 17 coconuts per year in 1931 to 57 in 1932, and 1933.

Table 4 shows the total and average production of coconuts, as well as the average price per 1,000 coconuts, for each of the harvesting periods covering the nine years, 1929 to 1937. It is interesting to note the trend of production of coconuts during the year on this farm. Production was at its lowest ebb during March and April. It gradually increased until it reached its peak in July and August; then, it declined slightly in September and October and continued to decrease further through November and December and January and February until it went back to its lowest point in March and April. This cycle of production may be more clearly seen from chart 1.

The above performance of coconut trees on the farm studied agreed with the findings of the Department of Agronomy, College of Agriculture, University of the Philippines. Data compiled for several years by that Department indicate that production of coconuts in certain places in Laguna was distributed among the six harvesting periods in the year as follows:[2]

On the farm of the College of Agriculture, the following production trend of coconuts was observed:

Harvesting periods in year	*Per cent of total production*
January—February	11.5
March—April	12.0
May—June	13.2
July—August	32.0
September—October	14.7
November—December	16.6
Total	100.0

On a farm in Calauang, Laguna, the following production trend was also observed:

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[2] The figures were furnished by Professor Pedro A. David of the Department of Agronomy.

Harvesting periods in year	*Per cent of total production*
March—April	10.0
March—April	10.0
May—June	15.0
July—August	25.0
September—October	25.0
November—December	15.0
Total	100.0

Again, figures compiled by the Department of Agricultural Economics on the receipts of copra at the Manila market from the coconut region of Laguna and Tayabas also reflect the above trend of coconut production in that region. The following figures show these receipts of copra:

Month	*Average total receipts*	*Per cent of average month receipts*
January	235,688	74.6
February	306,174	97.0
March	220,471	69.8
April	190,387	60.3
May	251,620	79.7
June	265,204	84.0
July	320,791	101.6
August	449,572	142.4
September	443,908	140.6
October	433,883	137.4
November	327,153	103.6
December	343,875	108.9

It may also be observed that the price of coconuts on this farm obeyed, almost perfectly, its inverse-proportional relationship with supply. The average price received per 1,000 coconuts from 1929 to 1937 was highest when production was at its lowest ebb during the March-April harvesting period. It gradually declined with the increase in production during the succeeding periods until it reached its lowest level at the peak of production during the July-August harvesting period. From this lowest point, it gradually rose as production decreased until it reached its highest level again in the March-April harvesting period (table 4 and chart 1). This close relationship between price and production indicates the strong influence of local market conditions upon the price of coconuts in the region.

Value received from the farm

The value received from the operation of the farm by the landlord consisted of two groups of items, namely, (*a*) cash obtained from the sale of crops and livestock, and (*b*) the increase in the inventory of the whole enterprise. The value received by the landlord from the sale of crops and livestock represents the amount left over after the shares of the tenants and all other cash expenses were deducted from the selling prices of these products. The increase in the inventory of the whole enterprise was due to increase in livestock, appreciation of the value of the coconut trees, and improvements of the farm. Table 2 shows the value received from the operation of the farm during the period from 1928 to 1937.

Sale of coconuts. Coconuts, being the main crop on this farm, brought the largest value to the landlord. The receipt from the sale of coconuts represented 79.97 per cent of the average annual value received from the operation of the farm during the period from 1929 to 1937.

The annual receipt from the sale of coconuts, of course, varied with the quantity harvested and the price at which the coconuts were sold. In 1929 the landlord realized ₱1,893.22 from 62,265 coconuts at an average price of ₱30.91 per thousand; in 1930 he received ₱1,411.87 for 54,936 coconuts at ₱25.96 per thousand; in 1931, ₱359.54 for 28,270 coconuts at ₱13.80 per thousand; in 1932, ₱923.52 for 100,888 coconuts at ₱9.33 per thousand; in 1933, ₱1,024.16 for 148,620 coconuts at ₱6.77 per thousand; in 1934, ₱529.74 for 86,524 coconuts at ₱5.73 per thousand; in 1935, ₱1,600.86 for 110,211 coconuts at ₱16.61 per thousand; in 1936, ₱2,239.51 for 119,916 coconuts at ₱19.00 per thousand; and in 1937, ₱2,484.01 for 107,478 coconuts at ₱27.11 per thousand (table 2).

Sale of bananas. The annual receipt from the sale of bananas was not very much, but it helped a great deal during the depression years, which coincided with the first five years after the acquisition of the farm by its present owner. In 1928, the receipt from the sale of bananas amounted to ₱22.80. It was ₱59.60 in 1929, ₱161.52 in 1930, ₱96.60 in 1931, ₱66.29 in 1932, ₱40.02 in 1933, ₱18.02 in 1934, ₱10.17 in 1935, ₱13.80 in 1936, and ₱13.95 in 1937 (table 2).

Sale of livestock. The receipt from the sale of cattle amounted to ₱70.00 in 1930, ₱367.00 in 1931, ₱90.00 in 1933, ₱81.00 in 1934, ₱124.60 in 1935, and ₱72.00 in 1936 (table 2).

Sale of firewood. Firewood brought to the landlord ₱15.00 in 1930, ₱16.50 in 1931, ₱18.00 in 1934, ₱8.25 in 1935, ₱36.22 in 1936, and ₱29.74 in 1937 (table 2).

Sale of house. A house purchased by the landlord on January 29, 1929, for ₱110.00 was sold by him for ₱38.00 on August 20, 1931.

Increase in inventory of the farm. This represents the appreciation in value of the farm. It is obtained by subtracting the inventory at the beginning from the inventory at the end of each year. In 1929, the increase in the inventory of the farm was ₱1,020.50. It was ₱325.00 in 1930, ₱3.64 in 1933, ₱18.33 in 1935, and ₱85.00 in 1936 (tables 2 and 3).

The records show that a purchase of an additional area of 4.2910 hectares at ₱3,500.00 was made on July 11, 1930. For the purpose of determining the income of the landlord, however, this sum was not considered as a part cf the increase in the inventory of the property. Since the purchase was made in the second half of the year, it was recorded both as an expense and as a receipt, in which case the two items cancelled each other when a balance sheet was taken. The sum, however, appeared as additional capital of the farm business for 1931.[3]

Total value received from the farm. This consisted of the total of all the amounts received from the sale of crops, livestock, and other products, and the increase in the inventory of the farm business. The total value received from the operation of the farm amounted to ₱22.80 in 1928, ₱2,973.32 in 1929, ₱1,983.39 in 1930, ₱377.64 in 1931, ₱989.81 in 1932, ₱1,157.82 in 1933, ₱646.76 in 1934, ₱1,762.21 in 1935, ₱2,445.53 in 1936, and ₱2,527.70 in 1937 (table 2).

Cash expenses of the farm

The cash expenses in connection with the operation of the farm whose records are the subject of this analysis include money spent for labor, interest on the unpaid balance of the purchase price of the land, taxes, transportation of laborers and materials, cost of seed and planting materials, miscellaneous expenses, decrease in the inventory of the property, and value of the farmer's labor. Table 2 shows the cash expenses of the farm. Exclusive of the value of the farmer's labor, which is treated separately in this analysis, the average annual cash expenses of the farm during the period from 1928 to 1937 were distributed among the following items as follows:

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[3] The authorities for this procedure are H. M. Dixon and H. W. Hawthorne in their work entitled, "A method of analyzing the farm business," published as United States Department of Agriculture, Farmers' Bulletin 1139. Washington, D. C., June, 1920, p. 12.

Item	*Per cent of total*
Labor	51.87
Interest on unpaid balance of purchase price of the land	21.18
Taxes	11.56
Transportation of labor and materials	1.12
Seed and planting materials	2.06
Decrease in inventory of the farm business	7.08
Miscellaneous expenses	5.13
Total	100.00

Expenses for labor. These include the shares of the tenants of the value of crops, animals, and other products sold from their respective holdings, the wages of extra labor employed for the improvement of the farm, and wages paid to the tenants for work which they performed for the landlord outside of their time on their respective holdings. In 1928, the labor expenses of the farm amounted to ₱66.00. They were ₱561.29 in 1929, ₱476.64 in 1930, ₱157.10 in 1931, ₱243.03 in 1932, ₱272.49 in 1933, ₱147.36 in 1934, ₱442.68 in 1935, ₱586.18 in 1936, and ₱626.25 in 1937 (table 2). As shown in the tabulation above, labor represented the largest item of expense of the farm, having constituted 51.87 per cent of the average annual cash expenses of the farm during the period from 1928 to 1937.

Interest paid. The largest portion of the farm—14.3335 hectares of it—was purchased for ₱14,000.00, payable in five annual installments in the following manner: A part of the purchase price, ₱1,460.00, was paid to the former tenant of this land and the remainder, ₱12,540.00, was paid to the former owner of the land in five equal yearly installments of ₱2,508.00, the remaining unpaid balance to earn interest at the rate of 7 per cent per annum. A part of the money used for the above installment payments was borrowed from the Philippine National Bank. The interest paid, therefore, refers to the interest of the money borrowed from the Philippine National Bank and that of the unpaid balance of ₱12,540.00. The interest paid by the present owner of the farm amounted to ₱80.17 in 1928, ₱702.24 in 1929, ₱395.84 in 1930, ₱439.61 in 1931, and ₱176.04 in 1932 (table 2).

Taxes paid. The landlord paid in taxes ₱3.60 in 1928, ₱21.53 in 1929, ₱88.95 in 1930, ₱101.04 in 1931, ₱101.06 in 1932, ₱75.80 in 1933, ₱75.80 in 1934, ₱91.61 in 1935, ₱91.61 in 1936, and ₱91.61 in 1937 (table 2).

Transportation of labor and materials. The cost of transportation of laborers and materials amounted to ₱2.65 in 1928, ₱46.30 in 1929, ₱14.80 in 1930, ₱11.90 in 1931, ₱7.20 in 1932, ₱2.14 in 1933, ₱4.40 in 1934, ₱4.47 in 1935, ₱3.67 in 1936, and ₱2.00 in 1937 (table 2).

Seed and planting materials. The expenses for seed represent the value, at current prices, of harvested coconuts which were retained for seed. The expenses for planting materials represent the value paid for lanzones seedlings which were purchased for planting between the coconut trees on the farm. The total cash outlay for both seed and planting materials amounted to ₱282.75 in 1929, ₱32.86 in 1930, and ₱4.50 in 1931 (table 2).

Decrease in inventory. During the period from 1928 to 1937, the inventory of the farm showed a decrease in only two years, in 1931 and 1934. The decrease in inventory in 1931, which was caused by the removal of some cattle through sale, amounted to ₱304.59; that in 1934, which was caused by the decrease in the value of the lanzones seedlings because of death and other injuries, was ₱153.64 (table 2).

Total cash expenses of the farm. The total cash outlay for the operation of the farm, which consisted of the total of the various expenses enumerated above, amounted to ₱158.54 in 1928, ₱1,672.39 in 1929, ₱1,033.65 in 1930, ₱724.80 in 1931, ₱850.12 in 1932, ₱379.07 in 1933, ₱439.40 in 1934, ₱630.86 in 1935, ₱688.56 in 1936, and ₱722.26 in 1937 (table 2).

It is seen that during the four years following the acquisition by purchase of the farm its present owner incurred a heavy expense annually. The payment of interest on the unpaid balance of the price of the land and on the money borrowed from the bank, and the purchase of lanzones seedlings accounted partly for this heavy expense. The high labor cost for the improvements on the farm during these initial years also was partly responsible for the heavy expense during these years.

Value of farmer's labor. This item includes the wages, transportation and other incidental expenses of the overseer, and the expenses of the landlord in connection with the inspection and management of the farm. The annual value of the farmer's labor amounted to ₱42.40 in 1928, ₱154.50 in 1929, ₱80.80 in 1930, ₱56.40 in 1931, ₱59.80 in 1932, ₱55.80 in 1933, ₱53.12 in 1934, ₱67.20 in 1935, ₱61.65 in 1936, and ₱67.02 in 1937 (table 2).

Interest earned by farm capital

By farm capital, as the term is used in this study, is meant the averge farm capital, which consists of the sum of the inventory at the beginning of each year and one-half of the total cash expenses of the farm during the same year. The interest earned by the farm capital is obtained by subtracting the value of the farmer's labor from the gross income.

No interest was earned by the farm capital in 1928. On the contrary, the total loss to the farm capital during this year amounted to ₱178.14. Because the farm was acquired by its present owner in the latter part of November of that year, no crop except bananas, brought any income to him. Moreover, improvements which had to be made on the farm required an expense greater than the value of the bananas sold. Hence, the above loss.

During the period from 1929 to 1937, however, the farm capital earned interest every year. The farm capital in 1929, which was ₱15,042.22, earned ₱1,146.43 as interest, or 7.62 per cent; that in 1930, ₱15,743.08, earned ₱906.94, or 5.76 ped cent; that in 1931, ₱19,413.66, earned ₱58.44, or 0.30 per cent; that in 1932, ₱19,324.02, earned ₱384.48, or 1.99 per cent; that in 1933, ₱18,936.20, earned ₱722.95, or 3.82 per cent; that in 1934, ₱18,970.01, earned ₱154.24, or 0.81 per cent; that in 1935, ₱18,912.10, earned ₱1,064.15, or 5.63 per cent; that in 1936, ₱18,959.28, earned ₱1,696.32, or 8.96 per cent; that in 1937, ₱19,061.13, earned ₱1,738.42, or 9.12 per cent (table 3).

Farming is considered successful when the income from it returns to the farmer his cash expenses, the value of his labor, and over and above this, an amount which is sufficient to pay interest on his capital at the rate of from 4 to 6 per cent per annum. On this basis, and excepting the worst years of the depression 1931 to 1934 inclusive, the farm herewith studied may be said to be fairly successful. The business position of this farm may be more appreciated if we consider the fact that during the depression years, 1930 to 1934, many coconut farms in the provinces of Laguna and Tayabas are said to have been unable to bring to their owners sufficient income to pay even the taxes on them.

Net profit or loss from the farm

The interest which was supposed to be earned by the farm capital at 7 per cent per annum (rate charged on mortgages by the Philippine National Bank) was as follows: For 1928, for a period of only 41 days from November 21 to December 31, ₱112.29; for 1929, ₱1,052.95; for 1930, ₱1,102.01; for 1931, ₱1,338.96; for 1932, ₱1,352.68; for 1933, ₱1,325.53; for 1934, ₱1,327.90; for 1935, ₱1,323.85; for 1936, ₱1,327.15; for 1937, ₱1,334.28 (table 3).

Adding the above interest earned annually by the farm capital to the total annual cash expenses of the farm and the value of the farmer's labor, we have the total annual farm expenses, which amounted to ₱313.23 in 1928, ₱2,879.84 in 1929, ₱2,216.46 in 1930, ₱2,120.16 in 1931, ₱1,958.01 in 1932, ₱1,760.40 in 1933, ₱1,820.42 in 1934, ₱2,021.91 in 1935, ₱2,077.36 in 1936, and ₱2,125.56 in 1937 (table 3).

The annual net profit from the operation of the farm amounted to ₱369.17 in 1936, and ₱404.14 in 1937. On the other hand, there was a net loss of ₱290.43 in 1928, ₱93.48 in 1929, ₱195.07 in 1930. ₱1,280.52 in 1931, ₱978.20 in 1932, ₱602.53 in 1933, ₱1,173.66 in 1934, and ₱259.70 in 1935.

If the total net profit, ₱773.31, is compared with the total net loss, ₱4,873.59, it will be seen that the farm is supposed to have incurred a total loss to its owner amounting to ₱4,100.28 during the period from 1928 to 1937.

But the figures above do not show the true business position of this farm during the whole period mentioned above. The farm was purchased during prosperous years, when the price of coconut lands was very high. When the effect of the world economic depression began to be felt in the Philippines in 1930, the price of such lands became very low. In fact, coconut lands in the province of Laguna which sold for about ₱1,000.00 a hectare in 1928 to 1929 were sold from 1931 to 1935 for about half of that amount, or even less. But the purchase price of the farm, not its actual market value, was used in taking its inventory during those depression years, 1931 to 1935 inclusive. Consequently, the capital of the farm was rather too large. In other words, the farm may be said to have been overcapitalized during those depression years.

To show the true business position of the farm during those depression years, its actual market value and not its purchase price would have been used for taking the inventory of the property. Assuming one-half of the purchase price (one-half of ₱18,250.00) to be the actual market value of the farm during the years 1931 to 1935 inclusive, the inventory of the property would be materially reduced and the farm capital would be ₱10,288.66 in 1931, ₱9,650.09 in 1932, ₱9,811.20 in 1933, ₱9,845.01 in 1934, and ₱9,787.10 in 1935. The interest which the above adjusted farm capital would earn, were it loaned at the current bank rate of 7 per cent per annum, was ₱720.21 in 1931, ₱675.51 in 1932, ₱686.78 in 1933, ₱690.15 in 1934, and ₱685.09 in 1935. The total farm expenses would have been ₱1,501.41 in 1931, ₱1,280.84 in 1932, ₱1,121.65 in 1933, ₱1,182.67 in 1934, and ₱1,383.15 in 1935.

With this adjustment, the true business position of the farm during the period from 1928 to 1937 would have been as follows: It would have brought to the landlord a net profit of ₱36.17 in 1933, ₱379.06 in 1935, ₱369.17 in 1936, and ₱404.14 in 1937. On the other hand, the farm would have incurred to the landlord a net loss of ₱290.43 in 1928, ₱93.48 in 1929, ₱1,273.45 in 1930, ₱661.77 in 1931, ₱291.03 in 1932, and ₱535.91 in 1934. Comparing the net profit, which amounted to ₱1,188.54, with the net loss, which totalled ₱3,146.07, it will be seen that the landlord would have incurred a net loss of only ₱1,857.53, instead of ₱4,100.28 without the above adjustment, during the period from 1928 to 1937.

Farmers, however, do not go this far to determine the success or failure of their businesses. As a rule, when the income from a farm returns to the farmer his cash expenses, pays for his own labor, and still an amount is left over to pay interest on the capital invested in the farm business at the rate of 4 per cent per annum, such a farm is considered successful. Since it has already been shown that the farm, whose records are herewith studied, has produced an annual income which, with the exception of the depression years, returned to its owner all of the above expenses, the above figures showing net profit and net loss do not disprove that the farm has been fairly successful.

Cost of production of coconuts

It has already been stated elsewhere in this paper that coconuts constitute the main crop on the farm being studied. A study of the efficiency of the farm, therefore, has been based on the cost of production of this main crop.

Table 3 shows the cost of production of coconuts. The average annual cost of production of coconuts per hectare during the period from 1929 to 1937 ranged from ₱10.70 to ₱76.35, the figures for each year being ₱76.35 in 1929, ₱59.63 in 1930, ₱35.14 in 1931, ₱25.98 in 1932, ₱15.73 in 1933, ₱10.70 in 1934, ₱24.86 in 1935, ₱32.90 in 1936, and ₱36.28 in 1937 (table 3).

The average annual cost of production per thousand coconuts during the same period, 1929 to 1937, ranged from ₱2.11 to ₱24.74, the figures for each year being ₱19.15 in 1929, ₱16.95 in 1930, ₱24.74 in 1931, ₱5.12 in 1932, ₱2.11 in 1933, ₱2.46 in 1934, ₱4.49 in 1935, ₱5.46 in 1936, and ₱6.72 in 1937 (table 3).

At the average annual prices prevailing during that period, the gross income of the owner of the farm from coconuts per year per hectare was ₱44.89 in 1929, ₱30.78 in 1930, ₱20.41 in 1932, ₱35.72 in 1933, ₱15.91 in 1934, ₱55.56 in 1935, ₱79.60 in 1936, and ₱88.50 in 1937. There was a gross loss of ₱17.08 in 1931. The landlord's gross income from coconuts per thousand was ₱11.76 in 1929, ₱9.01 in 1930, ₱4.21 in 1932, ₱4.66 in 1933, ₱3.27 in 1934, ₱12.12 in 1935, ₱13.54 in 1936, and ₱20.39 in 1937. There was a gross loss of ₱10.94 in 1931 (table 3).

Reasons for the variation in the cost of production of coconuts.

The variation in the yearly cost of production of coconuts on this farm was due to the variation in yields of the coconut trees, the variation in prices of coconuts sold, and the effectiveness of labor. The variation in the yields of the coconut trees may have been due to several factors, among which may be mentioned the variation in weather conditions, the physical condition of the trees, etc. The variation in the prices of the coconuts sold may have been due to a number of factors which influenced the interaction of the forces of demand and supply that determined these prices, among which may be mentioned the variation in the purchasing power of buyers, variation in the total quantity of the product for sale during each year, etc. The factors causing the variation in the yields of the coconut trees, as well as those causing the variation in the prices of coconuts, are beyond the control of the farmer. Consequently, he could not do anything to prevent them from affecting his business.

But the effectiveness of labor is within the control of the farmer. With cost records as a guide the farmer can make adjustments in his labor force so that he may get the most out of the money spent for laborers. The owner of the farm, which is the subject of this study, had apparently made use of his cost records as his guide in using labor. During the period from 1931 to 1934 inclusive, when the price of coconuts was low, the yearly average ranging from ₱5.73 to ₱13.80 per thousand, the amount spent for labor on the farm per year was correspondingly reduced. This expense for labor was less in spite of the greater yearly production, than during the years of high prices. The total amount of coconuts produced during these four years, 1931-1934, was 364,302, or an annual average of 91,175. The total expense for labor to produce this number of coconuts was ₱819.98, or an average of ₱2.25 per thousand nuts. On the other hand, during the years 1929 to 1930 and 1935 to 1937, when the price of coconuts was fairly high, the yearly average ranging from ₱16.61 to ₱30.91 per thousand, the amount spent for labor was correspondingly high. The total amount of coconuts produced during these five years was 454,806, or an average of 90,961 coconuts per year. The total amount spent for labor to produce this quantity of coconuts was ₱2,693.04, or an average of ₱5.92 per thousand. This amount is more than two times that spent for labor to produce the same number of coconuts during the depression years mentioned above, thus indicating that the owner of this farm attempted to make the most effective use of the labor force under his command. But such effective use of labor could not have been possible without the records of cost of production from year to year which served as a guide to the farmer.

SUMMARY AND OBSERVATIONS

This study has been based on the records of only one coconut farm. It is, therefore, impossible to make any definite conclusions from its results. However, there are certain tendencies observed in this study which, if studied further on the basis of a more extensive data to permit comparison, might prove conclusive relationships between costs and practices on this type of farm business. The analysis of the cost and practices of this farm may be summarized as follows:

1. The records indicate that this farm was fairly successful. It has been stated that on a majority of farms success is primarily dependent upon four important factors, namely: (*a*) size of business, (*b*) yield of crops, (*c*) returns from livestock, and (*d*) efficiency in the use of labor. Farm management studies have shown that the farmer whose business is efficient in these four factors is generally successful. However, the farms that have excelled in none of these factors usually fail. Those deficient in one or two may succeed, but their chances of success are greatly lessened. The farm

herewith studied apparently satisfied three of the above four factors of success of a farm business. It has already been shown that labor was efficiently employed on this farm. The yield of coconut trees on this farm was above the normal average yield of coconut trees in the coconut region of Laguna and Tayabas. The average annual yield of coconut trees on this farm during the period from 1929 to 1937, except in 1931 when it was 17, ranged from 36 to 57 coconuts. This is far above 34 coconuts, which is given as the average annual yield of coconut trees in the coconut region of Laguna and Tayabas under normal conditions. The farm also returned to the landlord a considerable amount from the sale of livestock (cattle). But, for lack of other farm records to compare with those of this farm, it cannot be stated whether such returns from livestock were sufficient or too small for the size of the enterprise. There are indications that the size of the farm is just about right for this type of farm business. Practically the whole area of the farm was planted to the main crop, coconut. The average yield of the coconut trees on the farm, as already stated above, was better than the average yield of coconut trees in the coconut region. Moreover, the income from the farm, of which 79.97 per cent is represented by the amount received from the sale of coconuts, returned to the owner his cash expenses, paid for his own labor, and returned an interest on the capital invested on the farm business better than 4 per cent, except during the depression years. Furthermore, if the size of the farming business was small, it will be larger when the lanzones plants between the coconut trees come to bearing. Although the actual area of the farm will not be increased by that time, nevertheless, the labor requirements of the farm business will be materially increased.

2. The cash expenses of the farm had a tendency to increase with the rise in the price of coconuts and decrease with the fall in the price of this main crop on the farm. The amount received from the sale of coconuts constituted the bulk of the yearly income from this farm. In fact, the value received from the sale of coconuts annually during the period from 1929 to 1937 represented from 40.96 per cent to 98.27 per cent, or an average of 79.97 per cent of the total annual receipt from the operation of the farm. The tenants' share of the selling price of coconuts produced from their holdings were included as part of the cash expenses for the operation of the farm. Since the amounts of the shares of these tenants were influenced by the price, as well as quantity, of coconuts, these tenants' shares

exerted an influence in making the cash expenses of the farm move in the same direction as the price of coconuts.

Another reason for the above behavior of the cash expenses of the farm to follow the rise and fall of the price of coconuts is that it is a usual tendency for business enterprises to increase their activities during periods of prosperity (high prices) and curtail some of their activities during periods of depression (low prices). The increase of activities during prosperous times means, of course, more outlay of money for labor. On the other hand, the curtailment of some activities during depression means decreased outlay for labor. The tenants' shares of the selling price of the coconuts produced from their holdings constituted a part of the labor expense of the farm. Moreover, there was really actual decrease in the labor force of the farm during the depression years and actual increase in this force during the prosperous years.

3. Labor is the most expensive factor required for crop production on this farm. This is perhaps explained by the fact that coconut farming, especially when the produce is sold as whole nuts, does not require much capital. During the period from 1928 to 1937, the labor expense constituted from 21.67 per cent to 86.70 per cent, or an average of 51.87 per cent of the total cash expenses for the operation of the farm (exclusive of the value of the farmer's labor).

4. The price of coconuts sold from this farm had a tendency to follow, with almost perfect regularity, its inverse proportional relationship with the quantity of this product disposed of. This perhaps indicates that local rather than world market conditions were the dominating influence in the determination of the price of coconuts when sold as whole nuts in the locality.

5. The records show that the owner of the farm treated his tenants like true partners in the business of farming. The tenants received their shares of the proceeds of the sale of their produce promptly upon receipt of the selling prices of such produce. They helped in the selling of their produce in that they were represented in the bargaining with the buyers. They received one-third of the proceeds of the sale of their produce, when the expenses of harvesting and selling had been borne by them; they obtained one-fourth of these proceeds, when the above expenses had been borne by the buyer. Whenever the tenants had to do some work for the landlord which took their time away from their holdings the landlord paid them regular wages for such work. The tenants were also en-

couraged by the landlord to use their initiatives. Those of them who showed special interest in the care and improvement of their holdings were liberally rewarded. On the other hand, those who were very careless were punished by fines, which were deducted from their shares of the proceeds of the sale of their produce.

Apparently the tenants of this farm were satisfied with the treatment they received from their landlord, because the same tenants who were on the farm in 1928 were still there, according to the records, in 1937.

6. The minimum wage paid to the laborers of this farm was ₱1.20 a day. This wage was higher than the average rate paid to unskilled agricultural laborers in the province of Laguna before the depression, which was ₱1.19 a day in 1925, and about 63 per cent higher than the average daily wage of the same type of laborers in the same province during the depression, which was ₱0.74 in 1930. The laborers of the farm had been getting the above wage of ₱1.20 a day since 1928, or long before the Government had set the minimum wage of laborers in government projects at ₱1.00 a day. The owner of this farm, therefore, was already practicing the social justice principle long before the Government made it known to the people.

7. Coconuts, the main crop on the farm, are harvested after about every sixty days. There are, therefore, six harvesting periods in the year, namely: January-February, March-April, May-June, July-August, September-October, and November-December. The production of coconuts on this farm was low during the months of January to April, high during May to August, and medium during September to December. The above trend of production of coconut trees on this farm seems to coincide with the general trend of production of coconut trees in the coconut region of the provinces of Laguna and Tayabas, as confirmed by figures compiled by the Department of Agronomy, College of Agriculture, University of the Philippines, and also by the Department of Agricultural Economics of the same College.

TABLE 1

Showing annual production and average price per 1,000 coconuts from Imuc farm, 1929 to 1937

HARVESTING PERIODS IN YEAR	1929		1930		1931		1932		1933		1934		1935		1936		1937	
	Nuts produced	Price /1,000	Nuts produced	Price /1,000	Nuts produced	Price /1,000	Nuts produced	Price /1,000	Nuts produced	Price /1,000	Nuts produced	Price /1,000	Nuts produced	Price /1,000	Nuts produced	Price /1,000	Nuts produced	Price /1,000
		pesos		*pesos*		*pesos*		*pesos*		*pesos*		*pesos*		*pesos*		*pesos*		*pesos*
January-February	6,915	34.50	7,895	30.50	3,097	18.00	6,639	10.50	20,081	7.00	8,443	5.00	11,893	15.20	15,726	14.70	11,220	42.00
March-April	5,980	34.00	5,566	28.50	3,032	15.50	7,928	11.15	16,119	7.00	9,514	5.25	8,434	30.30	14,194	16.00	11,352	46.00
May-June	10,177	31.00	8,856	28.00	3,595	13.50	26,061	7.00	20,565	7.25	14,309	4.30	11,913	16.70	21,733	13.30	17,327	29.00
July-August	15,848	28.00	12,940	26.25	10,337	13.00	34,836	10.00	36,979	7.60	31,391	6.30	29,751	11.20	28,691	16.00	19,013	20.20
September-October	14,345	28.00	12,151	23.00	8,209	9.00	25,425	8.00	39,663	6.60	—	—	29,870	13.00	25,837	24.00	27,164	12.50
November-December	9,000	30.50	7,528	19.50	—	—	—	—	15,213	5.20	22,867	7.80	18,350	13.30	13,735	30.00	21,402	13.00
Total nuts, produced, average price per 1,000 in year	62,265	30.91	54,936	25.96	28,270	13.80	100,888	9.33	148,620	6.77	86,524	5.73	110,211	16.61	119,916	19.00	107,478	27.11
Number of bearing trees	1,216		1,520		1,650		1,780		1,930		2,080		2,150		2,150		2,150	
Average number of nuts produced per tree per year	51		36		17		57		41		51		51		57		50	

TABLE 2

Value received from and operating expenses of the Imuc farm, 1928-1937

ITEMS	1928	1929	1930	1931	1932
	pesos	*pesos*	*pesos*	*pesos*	*pesos*
Value received:					
Sale of coconuts	—	1,893.22	1,411.87	539.54	923.52
Sale of bananas	22.80	59.60	161.52	96.60	66.29
Sale of firewood	—	—	15.00	16.50	—
Sale of livestock	—	—	70.00	367.00	—
Sale of house	—	—	38.00	—	—
Total sales	22.80	1,952.82	1,696.39	839.64	989.81
Increase in inventory	—	1,020.50	325.00	—	—
Total value received	22.80	2,973.32	2,021.39	839.64	989.81
Money spent for farm:					
Labor	66.00	561.29	476.64	157.10	243.03
Interest paid on purchase price of farm	80.17	702.24	395.84	439.61	176.04
Taxes paid	3.60	21.53	88.95	101.04	101.06
Transportation of labor & material	2.65	46.30	14.80	11.90	7.20
Seed and planting material	—	282.75	32.86	4.50	—
Miscellaneous	6.12	58.28	24.56	10.65	18.20
Total	158.54	1,672.39	1,033.65	724.80	545.53
Decrease in inventory	—	—	—	304.69	—
Total expenses of the farm	158.54	1,672.39	1,033.65	1,029.39	545.53
Value of farmer's labor [a]	42.40	154.50	80.80	56.40	59.80

[a] The value of the farmer's labor is treated here to include the wages and transportation of the overseer for supervision and other errands in connection with the operation and management of the farm, plus the expenses of the owner for inspection and consultation in connection with the purchase of the farm.

TABLE 2 (continued)

ITEMS	1933	1934	1935	1936	1937
	pesos	*pesos*	*pesos*	*pesos*	*pesos*
Value received:					
Sale of coconuts	1,024.16	529.74	1,600.86	2,239.51	2,484.01
Sale of bananas	40.02	18.02	10.17	13.80	13.95
Sale of firewood	—	18.00	8.25	36.22	29.74
Sale of livestock	90.00	81.00	124.60	72.00	—
Sale of house	—	—	—	—	—
Total sales	1,154.18	646.76	1,743.88	2,361.53	2,527.70
Increase in inventory	3.64	—	18.33	85.00	—
Total value received	1,157.82	646.76	1,762.21	2,446.53	2,527.70
Money spent for farm:					
Labor	272.49	147.36	442.68	586.18	626.25
Interest paid on purchase price of farm	—	—	—	—	—
Taxes paid	75.80	75.80	91.61	91.61	91.61
Transportation of labor & material	2.14	3.40	4.47	3.67	2.00
Seed and planting material	—	—	—	—	—
Miscellaneous	28.64	59.20	92.10	7.10	2.40
Total	379.07	285.76	630.86	688.56	722.26
Decrease in inventory	—	153.64	—	—	—
Total expenses of the farm	379.07	439.40	630.86	688.56	722.26
Value of farmer's labor	55.80	53.12	67.20	61.65	67.02

TABLE 3

Showing an analysis of the records of the Imuc farm, 1928-1937

DESCRIPTION OF ITEMS	1928	1929	1930	1931	1932
1. Inventory: January 1 December 31	 ₱14,205.76	₱14,205.76 15,226.26	₱15,226.26 15,551.26	₱19,051.26 18,746.67	₱18,746.67 18,746.67
2. Total coconuts produced	—	62,265	54,936	28,270	100,888
3. Average price per 1,000 nuts	—	₱ 30.91	₱ 25.96	₱ 13.80	₱ 9.33
4. Area of farm, hectares	14.3335	15.6154	15.6154	19.9064	19.9064
5. Total value received from farm including sales of products and increase in inventory	₱ 22.80	₱ 2,973.32	₱ 2,021.39	₱ 839.64	₱ 989.81
6. Value of farmer's labor	₱ 42.40	₱ 154.50	₱ 80.80	₱ 56.40	₱ 59.80
7. Total money spent for farm, including actual expenses and decrease in inventory (value of farmer's labor excluded)	₱ 158.54	₱ 1,672.39	₱ 1,033.65	₱ 724.80	₱ 545.53
8. Gross income from farm (5)-(7)	(Loss) ₱ 135.74	₱ 1,300.93	₱ 987.74	₱ 114.84	₱ 444.23
9. Interest earned by capital, (8) — (6)	(Loss) ₱ 178.14	₱ 1,146.43	₱ 906.94	₱ 58.41	₱ 384.48
10. Average farm capital: Inventory at beginning of year plus ½ of (7)	₱14,285.03	₱15,042.22	₱15,743.08	₱19,413.66	₱19,324.02

TABLE 3 (continued)

DESCRIPTION OF ITEMS	1928	1929	1930	1931	1932
11. Rate of interest earned by capital (9)/(10) × 100	1.24%	7.62%	5.76%	0.30%	1.99%
12. Total farm expenses:					
a. (7)	₱ 158.54	₱ 1,672.39	₱ 1,033.65	₱ 724.80	₱ 545.53
b. (6)	42.40	154.50	80.80	₱ 56.40	59.80
c. Interest, 7% on (10)	112.29 [a]	1,052.95	1,102.01	1,338.96	1,352.68
Total	₱ 313.23	₱ 2,879.84	₱ 2,216.46	₱ 2,120.16	₱ 1,958.01
13. Net gain (+) or loss (—) from farm: (5) — (12)	—₱ 290.43	—₱ 93.48	—₱ 195.07	—₱ 1,280.52	—₱ 978.20
14. Value of coconuts sold	None	₱ 1,893.22	₱ 1,411.87	₱ 359.54	₱ 923.52
15. Value of coconuts produced per hectare	—	₱ 121.24	₱ 90.41	₱ 18.06	₱ 46.39
16. Cost of production of coconuts: (12) — (expenses other than for coconut production)	—	₱ 1,192.48	₱ 931.25	₱ 699.54	₱ 517.33
17. Cost of production of coconuts per hectare	—	₱ 76.35	₱ 59.63	₱ 35.14	₱ 25.98
18. Gross income from nuts per hectare: (15) — (17)	—	₱ 44.89	₱ 30.78	₱ 17.08	₱ 20.41
19. Cost of production of coconuts per 1,000	—	₱ 19.15	₱ 16.95	₱ 24.74	₱ 5.12
20. Gross income from nuts per 1,000: (3) — (19)	—	₱ 11.76	₱ 9.01	₱ 10.94	₱ 4.21

[a] Interest of farm capital from November 21-December 31, 1928, or for 41 days only.

TABLE 3 (continued)

DESCRIPTION OF ITEMS	1933	1934	1935	1936	1937
1. Inventory: January 1 December 31	₱18,746.67 18,750.31	₱18,750.31 18,596.67	₱18,596.67 18,615.00	₱18,615.00 18.700.00	₱18.700.00 18,700.00
2. Total coconuts produced	148,620	86,524	110,211	119,916	107,478
3. Average price per 1,000 nuts	₱ 6.77	₱ 5.73	₱ 16.61	₱ 19.00	₱ 27.11
4. Area of farm, hectares	19.9064	19.9064	19.9064	19.9064	19.9064
5. Total value received from farm including sales of products and increase in inventory	₱ 1,157.82	₱ 646.76	₱ 1,762.21	₱ 2,446.53	₱ 2,527.70
6. Value of farmer's labor	₱ 55.80	₱ 53.12	₱ 67.20	₱ 61.65	₱ 67.02
7. Total money spent for farm, including actual expenses and decrease in inventory (value of farmer's labor excluded)	₱ 379.07	₱ 439.40	₱ 630.86	₱ 688.56	₱ 722.26
8. Gross income from farm (5)-(7)	₱ 778.75	₱ 207.36	₱ 1.131.35	₱ 1,757.97	₱ 1,805.44
9. Interest earned by capital, (8) — (6)	₱ 722.95	₱ 154.24	₱ 1.064.15	₱ 1,696.32	₱ 1,738.42
10. Average farm capital: Inventory at beginning of year plus ½ of (7)	₱18,936.20	₱18,970.01	₱18.912.10	₱18.959.28	₱19,061.13

TABLE 3 (continued)

DESCRIPTION OF ITEMS	1933	1934	1935	1936	1937
11. Rate of interest earned by capital (9)/(10) × 100	3.82%	0.81%	5.63%	8.96%	9.12%
12. Total farm expenses:					
a. (7)	₱ 379.07	₱ 439.40	₱ 630.86	₱ 688.56	₱ 722.26
b. (6)	55.80	53.12	67.20	61.65	67.02
c. Interest, 7% on (10)	1,325.53	1.327.90	1.323.85	1,327.15	1,334.28
Total	₱ 1,760.40	₱ 1.820.42	₱ 2.021.91	₱ 2.077.36	₱ 2,123.56
13. Net gain (+) or loss (—) from farm: (5) — (12)	—₱ 602.58	—₱ 1,173.66	—₱ 259.70	+₱ 369.17	+₱ 404.14
14. Value of coconuts sold	₱ 1,024.16	₱ 529.74	₱ 1 600.86	₱ 2.239.51	₱ 2,484.01
15. Value of coconuts produced per hectare	₱ 51.45	₱ 26.21	₱ 80.42	₱ 112.50	₱ 124.78
16. Cost of production of coconuts: (12) — (expenses other than for coconut production)	₱ 313.23	₱ 213.12	₱ 494.89	₱ 654.96	₱ 722.26
17. Cost of production of coconuts per hectare	₱ 15.73	₱ 10.70	₱ 24.86	₱ 32.90	₱ 36.28
18. Gross income from nuts per hectare: (15) — (17)	₱ 35.72	₱ 15.91	₱ 55.56	₱ 79.60	₱ 88.50
19. Cost of production of coconuts per 1,000	₱ 2.11	₱ 2.46	₱ 4.49	₱ 5.46	₱ 6.72
20. Gross income from nuts per 1,000: (3) — (19)	₱ 4.66	₱ 3.27	₱ 12.12	₱ 13.54	₱ 20.39

TABLE 4

Average coconut production of the Imuc farm and average price per 1,000 coconuts during each of the harvesting periods, 1929-1937

JANUARY-FEBRUARY		MARCH-APRIL		MAY-JUNE	
Number of coconuts produced in period	Average price per 1,000	Number of coconuts produced in period	Average price per 1,000	Number of coconuts produced in period	Average price per 1,000
(Total) 91,828	₱19.65	(Total) 82,119	₱21.56	(Total) 134,536	₱16.67
(Average) 10,203		(Average) 9,124		(Average) 14,837	

JULY-AUGUST		SEPTEMBER-OCTOBER		NOVEMBER-DECEMBER	
Number of coconuts produced in period	Average price per 1,000	Number of coconuts produced in period	Average price per 1,000	Number of coconuts produced in period	Average price per 1,000
(Total) 219,786	₱15.39	(Total) 182,634	₱15.51 [a]	(Total) 108,095	₱17.04 [b]
(Average) 24,420		(Average) 22,833 [a]		(Average) 15,442 [b]	

[a] Averages for this harvesting period were based on eight years' harvest, there being no harvest during this period for 1934.

[b] Averages for this harvesting period were based on seven years only, there being no harvest recorded for this period in 1931 and 1932.

ANIMAL BREEDING METHODS USED IN THE FORMATION OF TYPES OF CATTLE SUITABLE FOR RAISING IN THE TROPICS[1]

MIGUEL MANRESA
Of the Department of Animal Husbandry

WITH FOUR TEXT FIGURES

A few years ago, the accepted method of animal production in the Philippines, was to import already well established breeds from temperate countries to be acclimated here. Despite opposition, however, the work on formation of new breeds gradually gained momentum not only in the Philippines but in other parts of the tropical world. And today we find a number of newly-created types and breeds of cattle in different countries, notable among which are: the Santa Gertrudis in the state of Texas, U. S. A., Africander in the Union of South Africa, and Red Scindi and Sahiwal in India. A brief summary of the methods of breeding which have led to the formation of these new breeds of cattle is here reported.

THE SANTA GERTRUDIS BREED

This breed of cattle was evolved at the King Ranch located in Texas, where Shorthorn and Hereford breeds of cattle had been kept in a pure state for at least thirty-five years (Kelley, 1932). In spite of close attention given to the breeding of these animals, it was found impossible to retain their size. Frequent introductions of fresh bulls from the best herds in the northern part of the United States and England proved ineffective in preventing degeneration of the stock. Not only did the size and type degenerate but the percentage of calving dropped steadily, frequently getting as low as 30 per cent. This fact notwithstanding, the method of pure breeding was adhered to in the hope that among the fifty thousand purebred Shorthorn and Hereford cattle on the King Ranch, some might finally become acclimated, since the climate in Texas, average annual temperature 19.9°C and humidity 68 per cent, was mildly subtropical.

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[1] General contribution from the College of Agriculture No. 688. Read before the Los Baños Biological Club, July 27, 1939.

Crossbreeding was not resorted to until a crossbred Brahman bull, with Nellore blood predominating, came to the King Ranch as a gift. This bull was turned loose in a herd of pure Shorthorn cows. It was found later that the offspring of this bull by Shorthorn cows were very attractive. Hence, it was decided to try crossing Indian cattle (Brahman) with selected Shorthorn on a larger scale. A very outstanding bull named "Monkey" was produced in this crossbreeding work. The present breed of Santa Gertrudis cattle at the King Ranch may be traced back to the bull, "Monkey" (Kelley, 1932; and Rhoad, 1938). A schematic diagram of the method used to develop the Santa Gertrudis breed is given below:

Method of breeding used in the formation of the Santa Gertrudis breed of cattle

Brahman-Durham-Shorthorn × Brahman-Shorthorn
1/2 7/16 1/16 | 1/2 1/2
("Monkey")

Brahman-Shorthorn × Brahman-Durham-Shorthorn
1/2 1/2 | 1/2 7/32 9/32

Brahman-Shorthorn × Brahman-Shorthorn-Durham
1/2 1/2 | 1/2 25/64 7/64

Brahman-Shorthorn-Durham [2]

THE PHILAMIN BEEF-DRAFT OX

The inability of well established breeds of cattle from temperate countries to live and reproduce normally in the Philippines led B. M. Gonzalez to devise a plan of crossbreeding with the object of determining the proportion of the different kinds of blood needed to produce an animal suitable for raising in the Philippines. The objective sought was a blend of the desirable characteristics of the western breed with cattle which can live in this country (Tuason, 1926). In Texas, the Hereford degenerated in size, but in the Philippines they generally died (Villegas, 1933). The higher annual temperature of the Philippines (26.9°C and over) than that of Texas may account for this difference. In the native home of the Hereford the average annual mean of temperature is 9.3°C; humidity is 84 per cent.

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[2] Rigid selection was started beginning with the offspring of this generation. The work resulted in the formation of the Santa Gertrudis breed which has now been found suitable for raising, not only at King Ranch, but in southern states of the United States where temperate breeds are not very profitable.

In the work on crossbreeding cattle in the College of Agriculture Hereford males originating from Texas were mated with first-generation hybrid females from crosses between Indian Nellore and Philippine native. The products from these crosses were bred with first generation hybrids from Indian Nellores × Herefords. After a reasonable number of hybrid progenies had been produced from these and other matings, it was found that the animals possessing one-half Hereford, one-fourth Nellore, and one-fourth Native were superior to all other combinations when judged on the basis of size, reproductive capacity, and duration of productive life. Accordingly, all cows possessing this blood composition were gathered together and the best five were placed in a separate herd headed by the best bull from matings between pure Hereford males and Indian Nellore females. The bull selected to head this herd was "Provincial Fair", No. 93, shown in fig. 1. These six animals constituted the foundation stock for the new breed of beef-draft

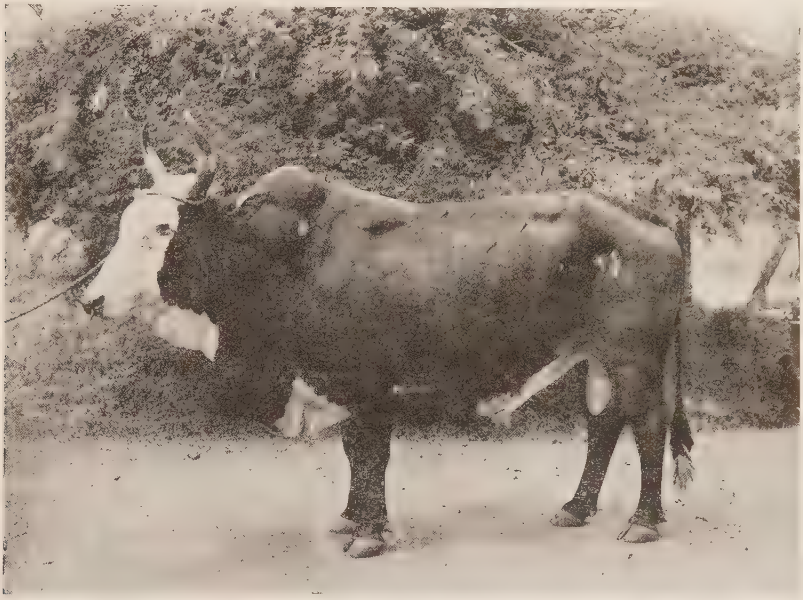

Fig. 1.—Foundation bull "Provincial Fair," or senior sire in the College of Agriculture, University of the Philippines, herd of Philamin beef-draft oxen.

oxen undergoing development in the College of Agriculture. The name Philamin was coined from the words Philippines, American and Indian (Manresa, 1934). A schematic diagram of the process involved in the formation of this breed follows:

Method of breeding used in the formation of the Philamin breed of beef-draft oxen

Philippine Native ----×---- Indian Nellore

Native-Nellore ----×---- Pure Hereford
1/2 1/2

Hereford ----×---- Indian Nellore

Native-Nellore-Hereford--×--Hereford-Nellore
1/4 1/4 1/2 1/2 1/2

Hereford-Nellore-Native[3]
1/2 3/8 1/8

ZEBU (BRAHMAN) CROSS CATTLE IN NORTH AUSTRALIA

The pastoral industry of the Northern Territory of Australia is said to have been initiated about fifty years ago. The nuclei herds were formed with cattle brought over from southern Australia, especially from Queensland. These and all other cattle which came into the territory later were British breeds. Slowly but steadily the cattle herds increased, and in 1932 there were about 700,000 cattle there (Kelley, 1932). If, however, the amount of labor and capital invested in the development of the cattle industry in the Territory which comprises over one-half million square miles is considered, the result can only be characterized as "woefully disappointing." In that time other portions of the continent of Australia had achieved results unparalleled in the northern portions bordering the tropics. Hence, it was concluded that natural conditions must have militated against this enterprise in the North. The climate in North Australia is tropical, the annual mean of temperature being 26.5 °C; while that of the South is temperate.

As a matter of necessity the formation of breeds suitable for raising in North Australia was started. Brahman (Zebu) and

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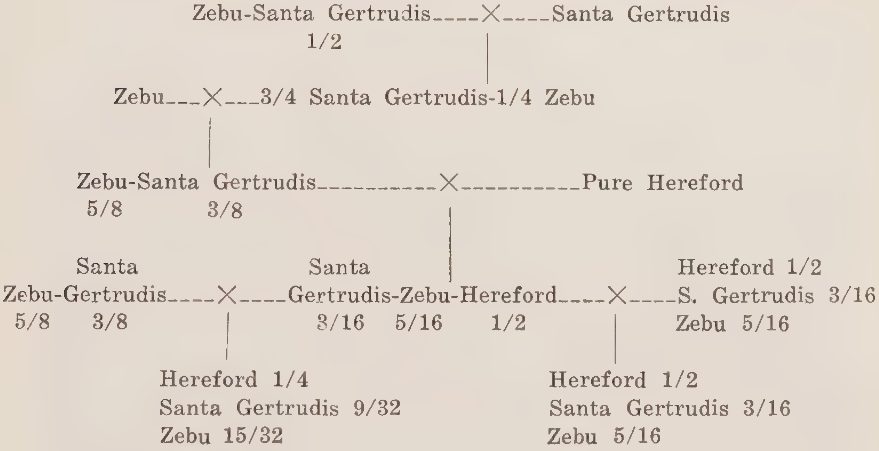
[3] Beginning with this generation individuals of this blood composition were mated *inter se*, and thereafter the blood composition of the progeny resulting was disregarded. Selection and culling were practised rigidly in order to fix the type for the breed. Fig. 2 shows a bull from the Philamin herd. This bull weighed 609 kilograms at maturity, 4 years and 9 months old.

Santa Gertrudis breeds were imported and crossed with British breeds. In one ranch, "Glen Prairie", the attempt has been to establish a group of hybrids having slightly less than one-half but more than one-quarter Zebu blood, since it has been found that animals of this blood composition are suitable for raising under the tropical environment prevailing in North Australia. A schematic outline of the process involved is shown below:

Method of breeding used at "Glen Prairie"
(North Australia)


Zebu-Santa Gertrudis 1/2
×
Santa Gertrudis
Zebu
×
3/4 Santa Gertrudis-1/4 Zebu
Zebu-Santa Gertrudis 5/8 3/8
×
Pure Hereford
Santa Zebu-Gertrudis 5/8 3/8
×
Santa Gertrudis-Zebu-Hereford 3/16 5/16 1/2
×
Hereford 1/2
S. Gertrudis 3/16
Zebu 5/16
Hereford 1/4
Santa Gertrudis 9/32
Zebu 15/32
Hereford 1/2
Santa Gertrudis 3/16
Zebu 5/16

By continuing and extending the series of matings shown above, two groups of hybrids arise: one possessing about one-half Hereford blood, the other 15/32 Zebu blood or nearly one-half (Kelley, 1938). The essential feature of the foregoing method is that it combines the methods used in the formation of the Philamin and Santa Gertrudis breeds of cattle. The former method attempted to maintain the Hereford blood in the proportion of about 50 per cent, whereas the latter has maintained the same average proportion of blood, namely one-half, in the Zebu.

THE RED SCINDI CATTLE

From a number of the newly created breeds of cattle intended for dairying, the best known in the Philippines at present is the Red Scindi (San Agustin, 1934; Villegas, 1935a). This breed was developed in the district of Karachi, province of Scindh, India, from a purely indigenous stock of cattle and without the introduction of foreign blood. It is reported that the ancestors of this breed were small sized animals (Matson, 1918). By methodically practising continual selection and culling, a fairly large animal yielding a reasonably large quantity of milk was evolved.

The average yield of three imported Red Scindi cows in the College of Agriculture from 1933 to 1938, inclusive, is well above five liters a day during a lactation period of not less than 300 days. Bulls of this breed in their original home weigh from 430 to 450 kilograms, cows from 300 to 350 kilograms. Exceptionally large bulls (see fig. 3) may weigh 660 kilograms at maturity. According to Littlewood (1936), "it is one of the purest and most distinct of the Indian breeds of cattle; it is moreover the only breed of commercially profitable dairy cattle in this country (India) outside of the buffaloes which can be purchased in large numbers."

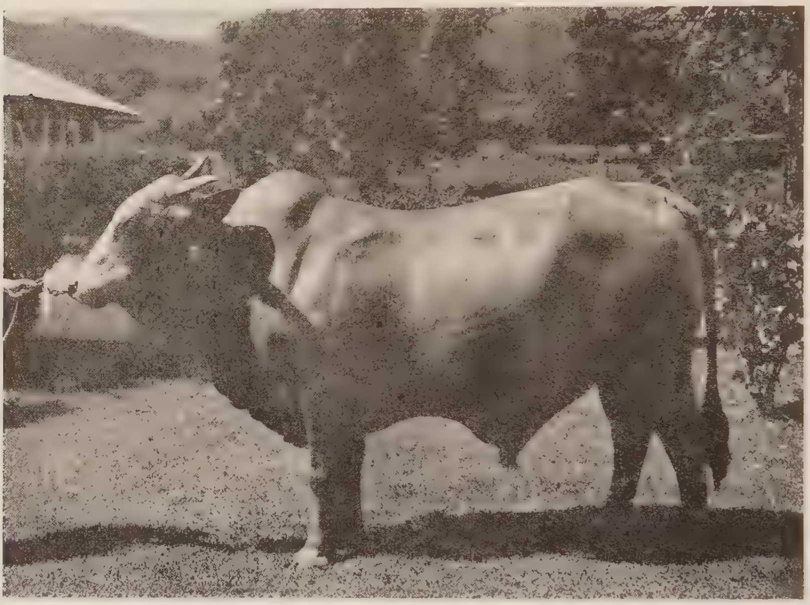


Fig. 2.—An outstanding bull "Marcos" produced in the Philamin herd of oxen. Son of "Provincial Fair" by Rebecca.

THE SAHIWAL BREED

During the trip through India made by the writer in the summer of 1937, he found that the Sahiwal breed of dairy cattle, formerly known as Montgomery, came next to the Red Scindi breed in point of number but not in individual performance as a milk producer. This breed traces its origin from one of the Punjab states, and the credit for the unification of type and increased production belongs to the Imperial Agricultural Research Institute which started to function in Pusa from where it was transferred to New Delhi, India. In 1913-1914 a herd of selected Sahiwal cows consisting of 49 head gave an average of only 2.6 liters of milk daily (5.8 lb.) during a lactation period of 44 weeks or 307 days. Under proper breeding methods and management the average milk yield of the herd improved steadily from 2.6 liters per cow per day in 1914 to 3.0 liters in 1918, 4.3 liters in 1923, and 5.7 liters in 1928.[4]

Special handling of the heifers and cows, beginning in 1932, accelerated the improvement of milk yield. Under such a method the average daily production per cow in the herd was raised from 6.17 liters in 1932 to 8.30 liters in 1934, and from 8.30 liters in 1934 to 9.56 liters in 1936 (Manresa, 1937). This method of special handling, among others, included (1) early training, (2) milking four times a day instead of two or three times, and (3) pre-milking, i. e. milking heifers and cows before they have dropped their calves (Sayer, 1937).

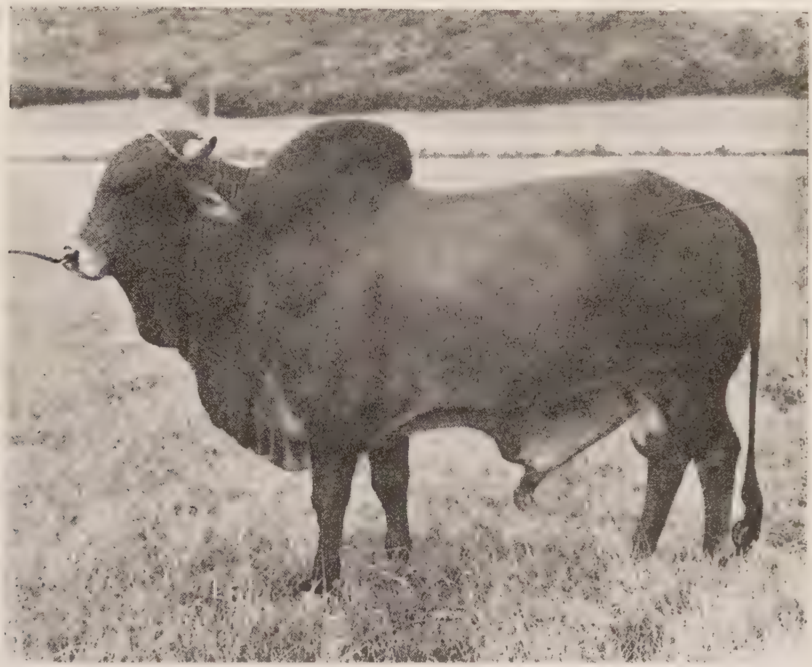


Fig. 3.—Red Scindi bull "Sawan" heading the herd of Red Scindi dairy cattle in the College of Agriculture, University of the Philippines.

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[4] General observations on animal husbandry in India. The Philippine Agriculturist **26**: 341–376.

At the time of the writer's visit to the dairy farm of the Imperial Agricultural Research Institute located at New Delhi, India, the cow rated as lowest producer in the herd of Sahiwal cattle yielded 2,260 liters in her previous lactation. The best cow in the herd was surpassing her previous lactation record of 4,536 liters. The average milk yield for the herd was 2,948 liters per cow lactation of 44 weeks duration, or 307 days (Manresa, 1937). One of the objects of the work of the Imperial Agricultural Research Institute in connection with this breed was to develop early maturity.

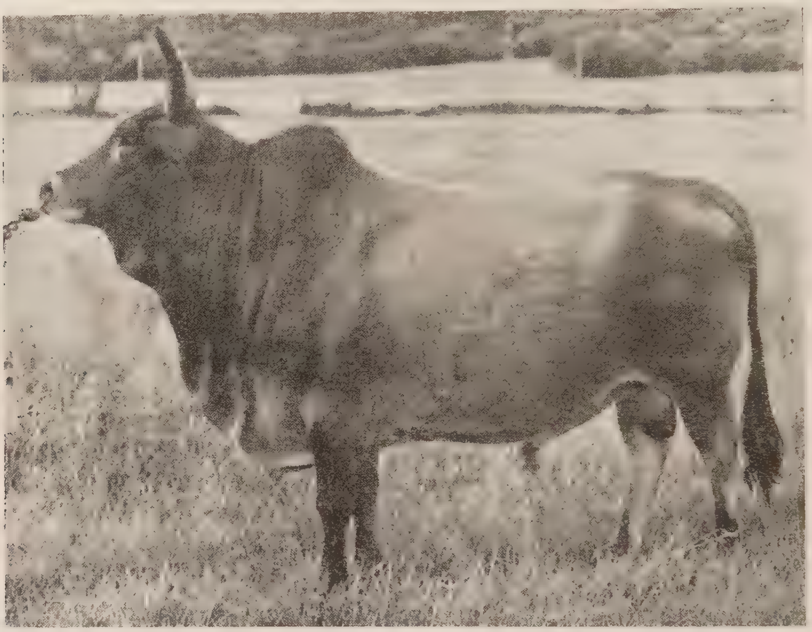

Fig. 4.—Philippine Native bull "Candelario" heading the heard of Batangas type of oxen in the College of Agriculture, University of the Philippines.

THE BATANGAS TYPE OF PHILIPPINE NATIVE OXEN

In this College, work on the improvement of Philippine Native cattle has been going on since 1919. In this work the method of selection and culling without introduction of exogenous blood is being used. The foundation animals were largely of the Batangas type since in that province the best stock of native oxen in the Philippines are found. The progenitors of these cattle are said to be of Mexican and Chinese origin introduced into the Philippines during the early years of the Spanish regime (Villegas, 1935b). In spite of inattention to breeding, care, and management, the cattle population in the Philippines increased steadily. In 1936 the number of cattle in the Philippines was well above one and one-half millions. Natural selection rendered these animals rather small in size. Bulls averaged 350 kilograms in weight at maturity. It was not so easy, therefore, to secure the bull of suitable weight, type, and conformation to head the foundation herd of native cattle. Search for this bull covered a period of several years over wide territory in the provinces of Batangas, Laguna, Rizal, and Tayabas. The bull finally selected is shown in fig. 4. This bull weighed 501 kilograms. The first step in this work has been to improve the size of the animals, and progress in this direction is being attained much faster than expected.

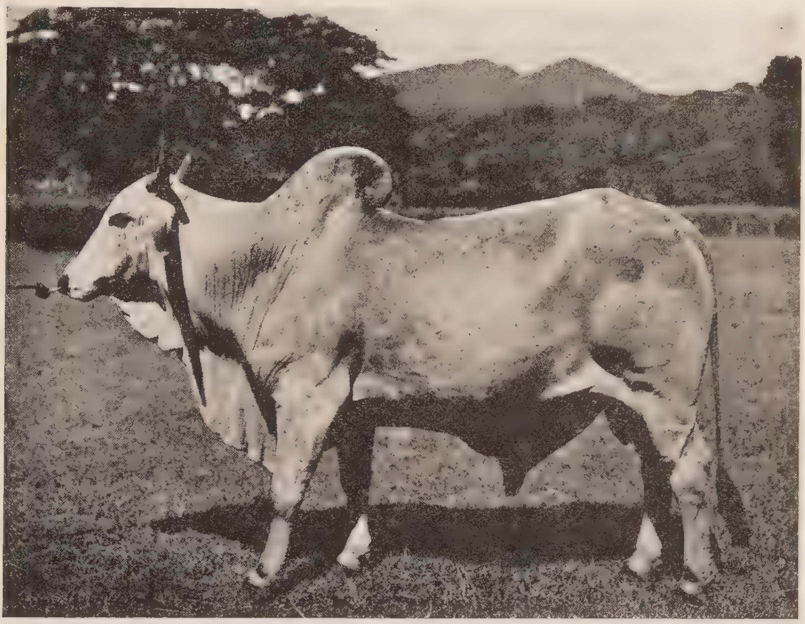

Fig. 5.—One of the Indian Nellore bulls "Madras Last" produced in the herd of this breed of cattle in the College of Agriculture. Weight, 644 kgm.

IMPROVEMENT ON THE INDIAN NELLORE BREED

The stock of Indian Nellore breed of cattle undergoing improvement in the College of Agriculture descended from those imported in large numbers by the Philippine Government from India in 1918. This importation consisted of 546 animals of which 224 were males (Alano, 1935). Two bulls and six cows were purchased by the College but steps towards the improvement of the stock were not taken until about six years later when the animals were first used in crossbreeding experiments involving Philippine and European cattle. After the nuclei herds for various projects had been formed, all the purebred Nellore still remaining were put together and a definite program for purposes of improvement was followed. This work has been going on for eleven years and the results indicate the existence of great possibilities for success in every productive direction. One of the bulls produced in the herd (See fig. 5) weighed 463 kilograms at the age of three and one-half years and 644 kilograms at maturity. The cropping out of many heifers with well developed udders is a great temptation for anyone who wishes to develop a dual-purpose breed of Nellore cattle suitable for the average Filipino farmer. In this herd of Nellores many heifers and cows owing to excess milk, have had to be milked after calving to save their udders from caking and their calves from scouring.

In India the Nellore cattle, called Ongole in that country, are not outstanding for milk production. Some fairly high yielders of milk, however, have been reported from time to time over wide territories. This justified the establishment of the Ongole Cattle Farm in 1918, in the district of Nellore, Madras Presidency (Littlewood, 1936). As a nucleus herd for the Ongole Cattle Farm forty-six selected cows and five bulls were put together and placed under close observation. After weeding out the irregular and late breeders twenty-five cows were retained. The heifers born to these cows were mated to good bulls. In 1931 the selected cows averaged 4.5 liters of milk daily during a rather short lactation period. By eliminating from the herd cows which produce milk for shorter periods, the average yield was improved, and five years later (1936) the daily production of the herd was increased by about 1.4 liters.

SUMMARY AND CONCLUSIONS

In the production and improvement of cattle suitable for tropical countries like the Philippines, two methods of breeding have been found to yield satisfactory results: (1) the improvement of the stocks of cattle which have become adapted to the environment prevailing in definite localities in each country, and (2) the formation or creation of new breeds by blending the desirable characteristics of the western breeds with those which can live in the tropics.

The practicability of these methods has been demonstrated in all parts of the tropical world. The former method, although slower, has the advantage of availability to the greatest number of live stock raisers, as it requires but little extra capital. The latter method is ordinarily more expensive because of the necessity of keeping many herds and a large number of animals in the herds as material for selection. Hence, this work has generally been left to institutions supported entirely or at least in part by governments.

In the adoption of either the first or the second method of breeding, it is important to keep in mind that little can be accomplished unless there is a well-defined policy governing the work and, above all, a permanent one. Failure in the past to achieve lasting results in animal improvement has been due to recurrent shifting of methods and objectives according to individual preferences and changing personnel. Hence, results accomplished through years of painstaking effort were quickly lost or nullified through whims or personal ambitions of new men who were not bound by well-defined goals and were always ready to launch a novel program for the sake of appearing original and efficient.

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HYBRID VIGOR IN THE FIRST GENERATION CROSSES BETWEEN STRAINS OF CEBU CORN [1]

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WITH ONE TEXT FIGURE

This paper constitutes the third of a series of studies on the utilization for planting purposes of first generation crosses between strains of Philippine corn. In the first paper (Capinpin and Padilla, 1938) it was reported that increased production of corn ear and shelled corn resulting from heterosis in F_1 hybrids of regional strains of Native Yellow Flint was realized in five combinations. The increase ranged from 7 to 38 per cent. In the second paper (Capinpin and Nakornthap, 1939) the increased yield of the F_1 hybrids of geographical strains of the Lagkitan corn was reported to be from 2 to 76 per cent. The present study deals with combinations of strains of Cebu corn.

Objects of the present work

This work was undertaken with the following objects: (*a*) to study the first generation crosses between the strains of Cebu corn in increasing corn production; (*b*) to find out whether or not the increased yields obtained, if any, are sufficiently great to pay for the added cost of producing first generation seeds.

Time and place of the work

The experiment was conducted in the Experiment Station field of the Department of Agronomy, College of Agriculture from May, 1937, to November, 1938, and included three plantings; the first was for hybridization, the second was of the F_1's planted during the dry season, and the third was of the F_1's during the wet season.

MATERIALS AND METHODS

Strains of corn used

Description of the variety. The Cebu Flint corn variety consists of different color strains, designated as Cebu White Flint, Cebu Yellow Flint, and Cebu Red Flint. All were named after the province of origin and color of the grains.

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[1] Experiment Station contribution No. 1322.

Description of the strains. The Cebu White Flint is characterized by the translucent white color of its grains. This strain is greatly preferred as food by the people in Cebu because its color resembles that of polished white rice. The Cebu White Flint produced tassels in fifty-one days after being planted at the College, and silk appeared between three and eight days after the tassels. The Cebu Red Flint, which has a red testa or hull, is also used as food by the people, but not so much as the Cebu White Flint. It produced tassels at approximately the same time as the Cebu White Flint, silk from three to seven days after the appearance of the tassels. The ears are smaller than the Cebu White Flint but larger than the Cebu Yellow Flint (figure 1). The Cebu Yellow Flint has yellow grains and is mostly used, roasted or boiled, while it is in the milk stage. It produced tassels in forty-nine days and silk in three to six days under College cultures. This was somewhat earlier maturing than the other two strains. The ear of this strain is smaller than that of any of the other two strains. The grains are smaller, too, but are somewhat compact and hard compared with those of the other two strains.

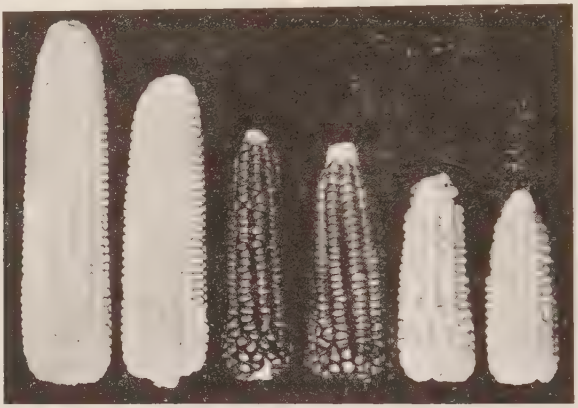

Fig. 1.—Showing strains of Cebu Native Flint corn used in the experiment (left to right, Cebu White, Cebu Red, and Cebu Yellow).

Seed corn received from Cebu province was used for these experiments.

Methods of making crosses and maintaining parental seed material

The hybrid seed was obtained by planting two strains of corn alternately in entire rows and detasseling the strain which was to produce hybrid seed. As soon as the tassels began to appear, they were pulled out before the anthers opened. The detasseled plants produced the hybrid seed.

Hybridization plots

Before planting, the land was plowed twice with native plows and harrowed once after each plowing. After the last harrowing, plots, each measuring 10 × 24 meters or 240 square meters, were laid out. The distance between the plots was four meters. Furrows were laid out lengthwise one meter apart. The space between the plots was planted to two rows of sorghum to provide a barrier against pollen grains from other plots. Eight furrows in each plot were planted to corn.

After the furrows had been laid out, planting began immediately. The different plots were planted with the strains as follows: Plot I, to Cebu White Flint and Cebu Red Flint alternately, the former being detasseled; Plot II, to Cebu Red Flint and Cebu Yellow Flint, the former being detasseled; and Plot III, to Cebu Yellow Flint and Cebu White Flint, the former being detasseled. Pollination was by wind and other natural agencies, not by an artificial process. The male plant rows were set so that the prevailing wind would carry the pollen from the undetasseled rows. Planting was done on May 21, 1937. In rows set one meter apart seeds were planted by hand at the rate of three to five per hill, seventy to eighty centimeters between hills.

On September 3, 1937, the treated and the untreated plots were harvested. The ears in plot I were piled into two groups, the crossbred pile (Red × White) F_1 harvested from the detasseled rows (the Cebu White Flint rows), and the parent pile (Cebu Red Flint) harvested from the undetasseled rows (Cebu Red Flint). In plots II and III, the same procedure was used as in plot I during the harvest.

After being harvested, the ears were husked and placed in sacks properly labeled for each treatment, after which they were taken to the Plant Breeding Laboratory room. After the ears had been thoroughly dried in the sun they were shelled by hand. Then the grains were placed in air tight containers.

Dry season test for F_1 hybrid seed compared with parents

The seeds of F_1 crossbred strains and of their parents were planted in plots replicated five times. Each plot had an area of 400 square meters (20 × 20). The land was located in the upland rice experiment station field about one hundred meters south of the fish pond. The area was 12,000 square meters. The field was plowed twice and harrowed after each plowing with native implements. After the furrows had been laid, planting began on December 14, 1937. The fields were divided into thirty plots. To equalize the effects of variation in soil, the plots occupied by parents and first generation hybrids were arranged in a checkerboard fashion. The planting was done by hand at the rate of from four to six seeds to a hill, allowing for thinning. The rows were one meter apart and the hills, from 70 cm. to 80 cm. apart. At the time of thinning, the plants were reduced to three to a hill. The amount of seed planted was recorded on March 28, 1938; the crops were harvested 104 days after planting.

Most of the first generation hybrids excelled their parents in germination. The plots located in the water-logged parts of the field had a poor germination; (Cebu Red × Cebu Yellow) F_1 had a good germination throughout the field. The parents had a fair germination, but in the water-logged section of the field, the germination was very poor.

In this culture, four plots of the different treatments were partly destroyed by stray carabaos and were not included in the computation. The strains of the damaged plots were the following: the (Cebu Red × Cebu White) F_1, the Cebu Yellow Flint, the (Cebu White × Cebu Yellow) F_1, and the Cebu Red Flint.

Wet season test for F_1 hybrid seed compared with the parents

Another piece of land located in the lot of the Sugar Cane Division was used for this planting. This was planted to sugar cane the preceding season. The area was 12,000 square meters, enough to contain thirty plots of 400 square meters each. The land was plowed twice and harrowed once with a tractor. For the last two plowings and harrowings, native implements were used. After the field had been properly prepared, planting began on May 24, 1938.

The procedure in planting was the same as that in the dry season planting.

Germination was quite uniform in all plots, and plants matured fairly well. On September 5, 1938 one hundred and six days after planting, the crops were harvested. Harvests of each plot were gathered separately and placed in sacks properly labeled. Then they were dried in the sun for about a week and weighed, after which they were shelled by a hand-operated machine. After being shelled, the grains were weighed again.

Determining profit or loss owing to the use of F_1 seed

The number of hours spent in detasseling was recorded in each of the hybridization plots, and the amount of good F_1 seeds was recorded. The results were as follows: (Cebu Red × Cebu White) F_1, six and two-thirds gantas; (Cebu Red × Cebu Yellow) F_1, six and three-fourths gantas; and (Cebu White × Cebu Yellow) F_1, four and one-half gantas. In the comparative planting, both for the dry and wet seasons, the amount of F_1 seeds was also recorded. At harvest time, in the dry and wet season comparative plantings, the increase of the yields of F_1 seeds over the parents was recorded by determining the average yields of parent strains and the F_1 strains.

RESULTS AND DISCUSSION

Height of parent strains and F_1 hybrids

During the dry season culture, results of which are partly shown in table 1, the first generation crosses were intermediate in height between their parents. In the wet season culture, however, the first generation crosses exceeded both parents in height (table 1). The degree of variability was noted in the parental strains and their hybrids.

Length of ears of parent strains and F_1 hybrids

The same result was found in the length of ear. Table 2 shows that the first generation crosses were intermediate in length of ear between their parents in the dry season planting. In the wet season culture, however, the ears of the crossbreeds were longer, with one exception, than their parents. The F_1 hybrid, which had shorter ears than both parents, was (Cebu White × Cebu Red) F_1.

Comparative yields of F_1 hybrids and parent strains

It will be noted in tables 3 and 4 that two plantings of the F_1 hybrid in all combinations gave an increase in yield of shelled corn over both parents. The increases, however, were not significant, with the exception of two combinations in wet season planting. The F_1 hybrids which gave a significant increase in yield over the parents were (Cebu Red × Cebu White) F_1 over Cebu White parent and (Cebu Red × Cebu Yellow) F_1 over Cebu Yellow parent.

The percentage of increase in the yield of the F_1 crosses over their lower yielding parents ranged from 11.64 per cent to 44.12 per cent, and the increase in yields of the F_1 hybrids, ranged from 12.88 per cent to 52.9 per cent. The average percentage of increase of F_1 hybrid ranged from 12.26 per cent to 48.51 per cent. In Native Yellow Flint, the F_1 crosses between regional strains had a range of 7.9 to 38.3 per cent (Capinpin and Padilla, 1938) whereas in the Lagkitan corn hybrid, Capinpin and Nakornthap (1939) found a range of 8.63 to 26.96 per cent.

From the data obtained in this experiment, it is evident that the utilization of first generation crosses between strains of Cebu corn should be encouraged, for all combinations have shown an increased production over both of their corresponding parents. But whether or not hybrid seeds should be utilized in commercial planting will depend upon whether the result from hybrid vigor will more than compensate for the labor spent in producing the hybrid seed.

Value of gain or loss in the use of F_1 hybrid seeds

Table 5 shows that in all plantings, with the exception of one combination in the dry season culture, there was a profit from F_1 hybrids when compared with both parents. The F_1 hybrid which gave a loss when compared with both parents was the (Cebu White × Cebu Yellow) F_1 planted during the dry season. In the wet season plantings all the hybrid seeds yielded more than their parents.

All combinations surpassed both parents in the first generation

Table 6 shows that all the F_1 hybrids surpassed their parents both in the dry and wet season plantings. It is noted in the dry season culture that the percentage of increase in the yield of the F_1 crosses over their lower yielding parents ranged from 11.64 per cent to 44.12 per cent, and the increase in the yield of the F_1 hybrids over the average of both parents ranged from 12.26 per cent to 48.51 per cent. During the wet season culture, the percentage of increase of the F_1 hybrids over both parents was a little lower than the dry season test. The average percentage of increase ranged from 16.31 per cent to 23.93 per cent.

Xenia effect

The xenia effect was shown in some crosses of different colors. In the F_1 seeds, some of the grains of the Cebu Red and the Cebu White were slightly red. In this combination, the Cebu Red was the male parent and the Cebu White, the female. No xenia effect was noted on Cebu Red pollinated with Cebu Yellow. Some of the grains, however, of the Cebu Red, which was the maternal parent, changed their color from dark to light red. A very clear xenia effect was exhibited by the cross between the Cebu White and the Cebu Yellow parents. The endosperm of the pollinated white corn became yellow.

SUMMARY AND CONCLUSION

The results reported in this paper may be summarized as follows:

1. An increase in height of plants and ear length of the F_1 hybrids over either or both parental strains was noted. The combination exceeded either the shorter parent or both parents in the two planting seasons.

2. The increase in production of the unshelled ear and shelled corn was obtained in all combinations resulting from hybrid vigor, although most of the increases were not significant. The increase of production of these F_1 hybrids over their parents ranged from 12.26 per cent to 48.51 per cent.

3. The extra cost of producing F_1 seed was more than compensated for by the increase in yield of F_1 hybrid, except the (Cebu White × Cebu Yellow) F_1 hybrid in the dry season planting, which showed a loss.

4. Xenia effect was exhibited by F_1 hybrid of the combinations (Cebu White × Cebu Yellow) F_1 and (Cebu White × Cebu Red) F_1.

5. Of the combinations tested, the (Cebu Red × Cebu Yellow) F_1 gave the highest yield of shelled grains and is recommended for the commercial production of seed corn.

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TABLE 1

Variation constants of height of parent strains and F_1 hybrids

PARENT STRAINS AND F_1 HYBRIDS	DRY SEASON CULTURE			WET SEASON CULTURE		
	Mean	Standard deviation	Coefficient of variation	Mean	Standard deviation	Coefficient of variation
	cm.	*cm.*	*per cent*	*cm.*	*cm.*	*per cent*
Cebu Red	89.64 ± 0.41	13.65 ± 0.29	15.24 ± 0.33	142.89 ± 0.48	15.94 ± 0.34	10.70 ± 0.23
Cebu White	81.31 ± 0.36	11.99 ± 0.25	14.74 ± 0.32	135.92 ± 0.59	19.76 ± 0.42	14.54 ± 0.31
Cebu Yellow	76.95 ± 0.30	9.08 ± 0.29	11.80 ± 0.28	148.13 ± 0.51	17.23 ± 0.36	11.63 ± 0.25
(Red × White) F_1 ..	81.65 ± 0.41	12.18 ± 0.29	13.70 ± 0.25	146.12 ± 0.61	20.26 ± 0.43	13.93 ± 0.34
(Yellow × Red) F_1 ..	88.78 ± 0.73	24.31 ± 0.52	27.38 ± 0.62	149.30 ± 0.49	16.25 ± 0.44	10.88 ± 0.23
(White × Yellow) F_1.	80.71 ± 0.38	11.41 ± 0.27	13.09 ± 0.36	152.06 ± 0.53	17.57 ± 0.37	11.57 ± 0.25

TABLE 2

Variation constants in length of ears of parent strains and F_1 hybrids

PARENT STRAINS AND F_1 HYBRIDS	DRY SEASON CULTURE			WET SEASON CULTURE		
	Mean	Standard deviation	Coefficient of veriation	Mean	Standard deviation	Coefficient of variation
	cm.	*cm.*	*per cent*	*cm.*	*cm.*	*per cent*
Cebu Red	7.85 ± 0.06	1.94 ± 0.04	24.77 ± 0.06	9.82 ± 0.06	2.02 ± 0.04	20.58 ± 0.45
Cebu White	6.71 ± 0.06	1.78 ± 0.04	26.59 ± 0.67	10.05 ± 0.20	6.65 ± 0.14	66.18 ± 1.93
Cebu Yellow	8.48 ± 0.21	6.97 ± 0.14	82.14 ± 1.53	9.19 ± 0.04	1.55 ± 0.03	16.21 ± 0.35
(Red × White) F_1 ..	7.70 ± 0.09	2.71 ± 0.06	35.32 ± 0.85	8.76 ± 0.06	2.01 ± 0.04	22.94 ± 0.51
(Yellow × Red) F_1 ..	8.43 ± 0.09	3.12 ± 0.06	37.05 ± 0.99	10.06 ± 0.07	2.41 ± 0.05	23.92 ± 0.53
(White × Yellow) F_1.	7.29 ± 0.08	2.48 ± 0.05	34.04 ± 0.90	10.25 ± 0.05	1.87 ± 0.03	18.26 ± 0.40

TABLE 3

Comparative yields of F_1 hybrids and parent strains, dry season culture

STRAINS	AVERAGE YIELD PER PLOT OF EAR CORN	DIFFERENCE	AVERAGE YIELD PER PLOT OF SHELLED CORN	DIFFERENCE	AVERAGE SHELLING PERCENTAGE	COMPUTED YIELD PER HECTARE OF CORN	DIFFERENCE	COMPUTED YIELD PER HECTARE OF SHELLED CORN		DIFFERENCE	
	kgm.	*kgm.*	*kgm.*	*kgm.*	*per cent*	*kgm.*	*kgm.*	*kgm.*	*cav.*	*kgm.*	*cav.*
(Red × White) F_1	14.5±1.86		10.4±1.57		72.41	362.50		262.50	4.56		
Cebu Red	11.5±1.32	+3.0±2.32	8.8±1.09	+1.7±2.09	76.52	287.50	75.00	220.00	3.83	42.5	.73
Cebu White	11.9±0.91	+2.6±2.07	8.4±1.53	+2.1±2.2	70.58	297.50	65.00	210.00	3.65	52.5	.91
(Yellow × Red) F_1	16.6±3.33		12.7±2.89		76.50	415.00		317.50	5.52		
Cebu Yellow	11.2±1.40	+5.4±3.47	8.3±1.03	+4.4±3.0	74.10	280.00	135.00	207.50	3.61	110.0	1.91
Cebu Red	11.5±1.32	+5.1±3.44	8.8±1.09	+3.9±3.0	76.52	287.50	127.50	220.00	3.83	97.0	1.69
(White × Yellow) F_1	12.4±1.62		9.35±1.11		75.40	310.00		233.75	4.07		
Cebu White	11.9±1.91	+0.5±2.51	8.4±1.53	+0.95±1.89	70.58	297.50	12.50	210.00	3.65	23.75	.42
Cebu Yellow	11.2±1.40	+1.2±2.14	8.3±1.03	+1.05±1.50	74.10	280.00	30.00	207.00	3.61	26.75	.46

+ .... Difference is in favor of hybrid.

TABLE 4

Comparative yields of F_1 hybrids and parent strains, wet season culture

STRAINS	AVERAGE YIELD PER PLOT OF EAR CORN	DIFFERENCE	AVERAGE YIELD PER PLOT OF SHELLED CORN	DIFFERENCE	AVERAGE SHELLING PERCENTAGE	DIFFERENCE	COMPUTED YIELD PER HECTARE OF CORN	COMPUTED YIELD PER HECTARE OF SHELLED CORN		DIFFERENCE	
	kgm.	*kgm.*	*kgm.*	*kgm.*	*per cent*	*kgm.*	*kgm.*	*kgm.*	*cav.*	*kgm.*	*cav.*
(Red × White) F_1	26.4±1.23		22.2±1.03		84.09	660.0		555.0	9.65		
Cebu Red	23.6±1.01	+2.8±1.59	19.5±1.80	+2.7±2.07	82.62	590.0	70.	487.5	8.47	67.5	1.18
Cebu White..............	23.3±0.54	+3.1±1.34	18.7±0.42	+7.5±1.10	80.26	582.5	77.5	467.5	8.13	87.5	1.52
(Yellow × Red) F_1	28.9±1.04		24.9±0.54		86.15	722.5		622.5	10.83		
Cebu Yellow..............	22.8±0.69	+6.1±1.26S	18.3±0.42	+6.6±0.68	80.26	570.0	152.5	457.5	7.95	165.0	2.88
Cebu Red.................	23.6±1.01	+5.3±1.05S	19.5±1.80	+5.4±1.87	82.62	590.0	132.5	487.5	8.47	135.0	2.39
(White × Yellow) F_1	28.2±2.16		23.5±1.84		83.33	704.0		587.5	10.21		
Cebu White	23.3±0.54	+4.9±2.22	18.7±0.42	+4.8±1.88	80.26	582.5	122.5	467.5	8.13	120.0	2.08
Cebu Yellow..............	22.8±0.69	+5.4±2.26	18.3±0.42	+5.2±1.88	88.26	570.0	135.0	457.5	7.05	130.0	2.26

+ ...... Difference is in favor of hybrid.

TABLE 5

Computed gain or loss per hectare from shelled corn from F_1 hybrid seeds

F_1 AND PARENT	DRY SEASON CULTURE				WET SEASON CULTURE			
	Computed increase (+) or decrease (—), in yield of F_1 hybrid	Value increase (+) or decrease (—) at ₱2.50 per cavan	Computed cost of producing seeds for one hectare	Profit (+) or loss (—) from the use of F_1 hybrid seeds	Computed increase (+) or decrease (—), in yield of F_1 hybrid	Value increase (+) or decrease (—) at ₱2.50 per cavan	Computed cost of producing seeds for one hectare	Profit (+) or loss (—) from the use of F_1 hybrid seeds
	cavan	*pesos*	*pesos*	*pesos*	*cavan*	*pesos*	*pesos*	*pesos*
(Red × White) F_1								
Cebu Dark Red	+ .73	+ 1.82	1.67	+ .15	+ 1.18	+ 2.95	1.67	+ 1.28
Cebu White	+ .91	+ 2.27	1.67	+ .60	+ 1.82	+ 3.80	1.67	+ 2.13
(Yellow × Red) F_1								
Cebu Yellow	+ 1.91	+ 4.77	2.07	+ 2.70	+ 2.88	+ 6.20	2.07	+ 4.13
Cebu Red	+ 1.69	+ 4.22	2.07	+ 2.18	+ 2.36	+ 5.80	2.07	+ 3.73
(White × Yellow) F_1								
Cebu White	+ .42	+ 1.05	2.07	— 1.01	+ 2.08	+ 5.20	1.67	+ 3.53
Cebu Yellow	+ .46	+ 1.16	2.07	— 0.91	+ 2.26	+ 5.65	1.67	+ 3.98

TABLE 6

Increase or decrease in the yields of F_1 hybrids over or below the yields of parent strains

F_1 AND PARENT	DRY SEASON CULTURE			WET SEASON CULTURE		
	Hybrid over (+) or below (−) lower yielding parent	Hybrid over (+) or below (−) higher yielding parent	Hybrid over (+) or below (−) average of parents	Hybrid over (+) or below (−) lower yielding parent	Hybrid over (+) or below (−) higher yielding parent	Hybrid over (+) or below (−) average of parents
	per cent	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*
(Red × White) F_1 ...						
Cebu Red	+ 19.06		+ 21.98	+ 13.03		+ 16.31
Cebu White		+ 24.90			+ 18.69	
(Yellow × Red) F_1 ..						
Cebu Yellow		+ 52.90			+ 36.23	
Cebu Red	+ 44.12		+ 48.51	+ 25.38		+ 23.93
(White × Yellow) F_1 .				+ 24.35		
Cebu White	+ 11.64		+ 12.26			+ 23.93
Cebu Yellow		+ 12.88			+ 23.43	

PASTURE WEEDS AND COST OF REMOVING THEM BY CUTTING[1]

JOSÉ M. BABARAN

Barsana (1925) found that one-fifth of the total pasture land of the College of Agriculture was useless because of the presence of weeds. Tabor (1922) found that weedy pastures indicate poor management and low fertility of soil. He further found that two or three cuttings of the weeds would reduce materially their number the next year.

In the experiments reported by Manresa *et al* (1938), under single treatments of pasture cleaning, grubbing gave the lowest amount of weeds, cutting next, and burning the largest quantity of weeds. Under combination treatments, cutting followed by burning and grubbing was as good in reducing the stand of weeds as burning, grubbing, and cutting.

Sampson (1914) states that a decline in the yield of pasture may be due to an excessive amount of weeds, to abnormal climatic conditions, to the handling of stock, or to various allied conditions.

Objects of the work

The objects of the work were: (*a*) to find out the species of undesirable vegetation infesting the hillside and plain pastures, (*b*) to determine the degree of infestation as indicated by the height and weight of the plants at the time they were cut, and (*c*) to ascertain the cost of removing them by bolos.

Time and place of the work

The experiment lasted from May 29, 1936, to May 17, 1937, approximately one year. It was conducted in the Department of Animal Husbandry.

MATERIALS AND METHODS

Pastures

Ten pastures were used: five on a hillside and five on level ground. The pastures were divided into ten one-hectare lots in the form of squares adjoining each other. The boundaries of each were marked with stakes 25 meters apart so as not to interfere with the grazing of the animals. The lots on the hillside were designated as pastures I, II, III, IV, and V, and those on the plain were marked similarly. Care was taken that the pastures were not over-grazed.

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[1] Experiment Station contribution No. 1323. Prepared in the Department of Animal Husbandry under the direction of Associate Professor Valente Villegas.

Kinds of vegetation

Both kinds of pastures had more or less similar vegetation. The undesirable plants were classified into major and miscellaneous weeds. All species weighing 25.00 kgm. or over at the time of cutting were designated as major weeds, whereas those below this weight were considered under the miscellaneous group. The pastures on the hillside were used for the dairy herd which consisted mostly of grade carabaos and cattle. Red Scindi and Philippine cattle grazed on the plain. The grasses in both pastures were similar, although in some, certain species were more prevalent than in others. The common plants were cogon [*Imperata cylindrica* (Linn.) Beauv. var. *koenigii* (Retz.) Benth.], talahib [*Saccharum spontaneum* Linn. subsp. *indicum* Hack.], Bermuda grass [*Cynodon dactylon* (Linn.) Pers.], carabao grass (*Paspalum conjugatum* Berg.), lisang-kalabao (*Panicum flavidum* Retz.), paragis [*Eleusine indica* (Linn.) Gaertn.), mutha (*Cyperus rotundus* Linn.), banig-usa [*Eragrostis viscosa* (Retz.) Trin.], macahia (*Mimosa pudica* Linn.), manimanihan [*Desmodium capitatum* (Burm. f. DC.] cauacauayan (*Apluda mutica* Linn.), dilang-baca (*Elephantopus scaber* Linn.), botobotonis (*Euphorbia hirta* Linn.), aguingay (*Rottboellia exaltata* Linn. f.), and alicbangon (*Cyanotis* sp.).

The major weeds in these pastures were: lantana (*Lantana camara* Linn.), barak [*Curcuma zedoaria* (Berg.) Rosc.], payang-payang babae [*Flemingia strobilifera* (Linn.) R. Br.], suag-kabayo (*Hyptis suaveolens* Poir.), sambong [*Blumea balsamifera* (Linn.) DC.], guava (*Psidium guajava* Linn.), pongapong (*Amorphophallus campanulatus* (Roxb.) Blm.), palis (*Callicarpa cana* Linn.), maguilic (*Premna cumingiana* Sch.), payang-payang lalake [*Desmodium pulchellum* (Linn.) Benth.], sambong-sambongan [*Blumea lacera* (Burm. f.) DC.], aroma [*Acacia farnesiana* (Linn.) Willd.], balatong-aso (*Cassia tora* Linn.), and kambali (*Hyptis capitata* Jacq.).

The miscellaneous weeds were: pandakake (*Tabernaemontana pandacaqui* Poir.), kasonpangil (*Clerodendron intermedium* Cham.), colotcolotan (*Triumfetta* sp.), escobang-bilog (*Sida retusa* Linn.), dilang-baca (*Elephantopus scaber* Linn.), marcela (*Ageratum conyzoides* Linn.), mankit [*Desmodium gangeticum* (Linn.) DC.], sili (*Capsicum frutescens* Linn.), uray (*Amaranthus spinosus* Linn.), bulak-manok [*Vernonia patula* (Dry.) Merr.], dilao (*Curcuma longa* Linn.) and hangod [*Stachytarpheta jamaicensis* (Linn.) Vahl] [2]

Implements

Bolos. Bolos of ordinary size and weight were used to cut the weeds. From time to time these were sharpened.

Pitching forks. Two light pitching forks with long handles were used in piling the weeds.

Scale. A Renfrew scale with a capacity of 2,000 lbs. (907.2 kgm.) was used for weighing purposes.

Weeding

Five months before the experiment started, the pastures had been cleaned as part of the usual program of the Department of Animal Husbandry, which puts its pasture areas into good condition after the rainy season. In this experiment, the weeds were cut as soon as they shaded the forage plants; that is, from time to time the height and density of the weeds were ascertained and as soon as they encroached seriously upon the grass, they were cut. Ten plants of each of the major weeds were measured on the first day of weeding, and the average height was recorded for the purpose of giving information on the comparative development of each species during both the dry and wet seasons. Two men of average efficiency were employed to cut the weeds which were removed in the order of their predominance as indicated by the density of their growth, their height, and the area covered in each pasture. The weeds were cut alternately in the lots on the hillside and plain. The time consumed in cutting those in each lot was recorded. Soon after being cut and piled, the major weeds were weighed separately. Those under the miscellaneous group were weighed together.

The cost of weeding was computed on the basis of ten centavos per hour.

The pastures were observed weekly to ascertain whether any new species of weeds had appeared and to determine when they should next be cut.

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[2] The weeds as well as the forage plants reported in this paper were identified by Dr. Jose B. Juliano of the Department of Agricultural Botany.

DISCUSSION OF RESULTS

Cutting periods

All pastures on the hillside, with the exception of pasture IV, were cut three times during the year. The first cutting in pasture I was from May 29, 1936, to July 14, 1936, the second from September 29, 1936, to October 6, 1936, and the third from February 4 to 5, 1937. In pasture II, the first cutting was from July 23, 1936, to August 17, 1936, the second from October 6 to November 4, 1936, and the third from January 29, 1937, to February 4, 1937. In pasture III, the first cutting was from August 22, 1936, to September 3, 1936, the second from November 4 to 6, 1936, and the third from January 16 to 22, 1936. The first cutting in pasture IV was from September 10 to 19, 1936, and the second from January 22 to 29, 1937. The first of the three cutting periods in pasture V was from September 25 to 26, 1936; the second from January 4 to 16, 1937, and the third from May 15 to 17, 1937. The interval between the first and the second cutting was shorter than that between the second and the third, and the first cutting took much longer than the following ones. This showed that the growth of the weeds apparently was greatly retarded by the previous cutting as well as by the lack of sufficient moisture in the soil during the dry season. The average time interval between the first and second cuttings was about 102 days whereas it was about 78 days between the second and third. This made a difference of 24 days. The average length of time each lot required for the first cutting was about 126 hours, for the second 66 hours, and for the third about 26 hours.

On the plain, the first cutting in pasture I took place from July 14 to 22, 1936, whereas the second was on February 6, 1937. In pasture II, the only cutting made was from August 18 to 22, 1936, and in pasture III, from September 4 to 10, 1936. In pasture IV, the first cutting was from September 21 to 25, 1936, the second from December 15 to 21, 1936, and the third from March 23 to 29, 1937. In pasture V, the first cutting took place on September 28, 1936, the second from December 21, 1936, to January 4, 1937, and the third from May 14 to 15, 1937. Except in pasture lots IV and V, no comparison can be made between the first and second intervals of cutting because after the first cutting in lots II and III, no weeds had grown to the size which necessitated second and third cuttings. Likewise lot I, after the second cutting, did not require a third. Lot IV required about the same interval between cuttings, whereas lot V required two months longer between second and third cuttings than between first and second.

Height of weeds

Hillside pastures. The average height of lantana in the different pastures on the hillside follows: In pasture I, it was 143.0 cm.; in pasture II, 140.5 cm.; in pasture III, 187.0 cm.; in pasture IV, 179.0 cm.; and in pasture V, 123.0 cm. The average height in all the pastures was 154.0 cm.

Of payang-payang babae, the average height was 65.3 cm. in pasture I, 66.3 cm. in pasture II, 63.0 cm. in pasture III, 60.0 cm. in pasture IV, and 55.6 cm. in pasture V. The average in all the pastures was 62.4 cm.

On the average, barak measured 57.3 cm. in height in pasture I, 58.0 cm. in pasture II, 47.3 cm. in pasture III, 44.0 cm. in pasture IV, and 34.0 cm. in pasture V. The average in all the pastures was 48.1 cm.

The average height of guava in pasture I was 93.0 cm.; in pasture II, 95.0 cm.; in pasture III, 52.0 cm.; in pasture IV, 54.0 cm.; and in pasture V, 55.0 cm. The average height in all the pastures was 69.8 cm.

Of sambong, the average height in pasture I was 64.0 cm.; in pasture II, 62.0 cm.; in pasture III, 61.0 cm.; in pasture IV, 54.0 cm.; and in pasture V, 56.0 cm. The average in all pastures was 59.0 cm.

On the average, suag-kabayo was 73.5 cm. in pasture I, 79.0 cm. in pasture II, 67.0 cm. in pasture III, and 72.5 cm. in pasture IV. The average height in all pastures was 72.0 cm.

The average height of palis in pasture II was 71.0 cm.; in pasture III, 87.0 cm.; in pasture IV, 70.0 cm.; and in pasture V, 54.0 cm. The average height in the four pastures was 73.0 cm. This was not a major weed in pasture I.

Pongapong, on the average, measured 72.0 cm. in height in pasture I, 78.0 cm. in pasture II, 73.0 cm. in pasture IV, and 63.0 cm. in pasture V. The average height in the four pastures was 71.5 cm. This was not a major weed in pasture III.

The average height of payang-payang lalake in pasture I was 89.0 cm.; in pasture II, 79.0 cm.; in pasture III, 58.0 cm.; and in pasture IV, 58.0 cm. The average height in the four pastures was 71.0 cm.

Maguilic measured, on the average, 73.0 cm. in pasture III and 101.0 cm. in pasture V; the average height in both pastures was 87.0 cm. This plant was not a major weed in the rest of the pastures.

Pastures on the plain. On the plain sambong ranked first in height with an average of 70.0 cm. in pasture I, 63.0 cm. in pasture II, 69.0 cm. in pasture III, 82.0 cm. in pasture IV, and 76.0 cm. in pasture V. The average in all pastures was 72.0 cm.

Guava in pasture I measured, on an average, 76.0 cm. in height; in pasture III, 71.0 cm.; in pasture IV, 66.0 cm.; and in pasture V, 55.0 cm. The average height in all pastures was 67.0 cm.

Payang-payang babae in pasture I had an average height of 63.0 cm.; in pasture II, 57.0 cm.; in pasture III, 68.0 cm.; in pasture IV, 61.0 cm.; and in pasture V, 60.0 cm. The average height was 61.8 cm.

Suag-kabayo had an average height of 85.0 cm. in pasture I, 67.0 cm. in pasture II, and 72.0 cm. in pasture III. The average height in the three pastures was 74.6 cm.

Of pongapong, which was found abundantly only in pastures IV and V, the average height was 67.0 cm. and 52.0 cm., respectively. The average in the two pastures was 59.0 cm.

In pastures IV and V, in which sambong-sambongan was a major weed, the average height was 63.0 cm. and 62.0 cm., respectively. The average in both pastures was 62.5 cm.

Palis in pastures IV and V had an average height of 60.0 cm. and 61.0 cm., respectively; the average was 60.5 cm.

The average height of payang-payang lalake was 65.0 cm. in pasture III, 70.0 cm. in pasture IV, and 55.0 cm. in pasture V. The average height was 63.3 cm.

Maguilic was a major weed only in pastures IV and V, and the average height was 147.0 cm. and 110.0 cm., respectively. The average height in both pastures was 128.0 cm.

Balatong-aso in pasture IV measured, on the average, 54.0 cm. in height and in pasture V, 48.0 cm. The average in both was 51.0 cm.

In general, it is evident that in all pastures there was a marked decrease in the height of the weeds after the first cutting. The slowest growth was toward the end of the experimental period.

Weight of weeds

Hillside pastures. The heaviest weed in all the pastures on the hillside was lantana. Its total weight as a major weed in pasture I during the year was 124.09 kgm.; in pasture II, 6,297.7 kgm.; in pasture III, 1,072.7 kgm.; in pasture IV, 1,804.09 kgm.; and in pasture V, 2,492.27 kgm. The average weight of the weed cut from each pasture during the year was 2,358.17 kgm.

Payang-payang babae in pasture I had a weight of 628.39 kgm.; in pasture II, 1,526.34 kgm.; in pasture III, 901.36 kgm.; in pasture IV, 1,115.45 kgm.; and in pasture V, 2,781.36 kgm. The average amount cut from each pasture during the year was 1,390.58

Barak ranked second to lantana. A total of 1,634.76 kgm. was cut in pasture I during the year, 195.5 kgm. in pasture II, 968.18 kgm. in pasture III, 2,009.09 kgm. in pasture IV, and 311.36 kgm. in pasture V. The average from each pasture was 1,021.87 kgm.

The weight of guava collected in pasture I was 105.45 kgm.; in pasture II, 137.72 kgm.; in pasture III, 423.18 kgm.; in pasture IV, 520.08 kgm.; and in pasture V, 1,521.36 kgm. The average weight of this weed from each pasture during the year was 541.55 kgm.

The weight of sambong in pasture I was 616.03 kgm.; in pasture II, 318.17 kgm.; in pasture III, 744.45 kgm.; in pasture IV, 343.61 kgm.; and in pasture V, 463.63 kgm. The average was 497.18 kgm. in each pasture during the year.

The weight of suag-kabayo in pasture I was 526.13 kgm.; in pasture II, 93.63 kgm.; in pasture III, 579.09 kgm.; and in pasture IV, 667.72 kgm. The average from each pasture was 372.91 kgm. during the year.

The amount of palis cut in pasture II weighed 409.45 kgm.; in pasture III, 225.90 kgm.; in pasture IV, 143.18 kgm.; and in pasture V, 750.44 kgm. The average weight from each pasture during the year was 305.79 kgm.

As much as 44.09 kgm. of pongapong was cut in pasture I, 535.89 kgm. in pasture II, 272.27 kgm. in pasture IV, and 262.27 kgm. in pasture V. The average amount from each pasture during the year was 222.90 kgm.

Payang-payang lalake cut in pasture I weighed 47.37 kgm.; in pasture II, 30.0 kgm.; in pasture III 233.18 kgm.; and in pasture IV, 196.35 kgm. The average was 101.38 kgm.

The amount of maguilic cut in pasture III was 118.18 kgm. and in pasture V, 222.27 kgm. The average weight in each pasture was 68.09 kgm.

The total weight of the miscellaneous weeds cut from each of the pastures during the year follows: in pasture I, 191.80 kgm.; in pasture II, 679.54 kgm.; in pasture III, 546.34 kgm.; in pasture IV, 524.99 kgm.; and in pasture V, 483.62 kgm. The average was 485.25 kgm. for each pasture during the year.

Pastures on the plain. The heaviest weight recorded for pastures on the plain was of sambong in pasture I; the amount cut was 101.36 kgm. In pasture II, it was 156.36 kgm.; in pasture III, 63.64 kgm.; in pasture IV, 4,500.35 kgm.; and in pasture V, 2,075.05 kgm. The average amount cut from each pasture during the year was 1,379.35 kgm.

The weight of payang-payang babae cut in pasture I was 122.01 kgm.; in pasture II, 75.0 kgm.; in pasture III, 305.55 kgm.; in pasture IV, 731.91 kgm.; and in pasture V, 738.17 kgm.; the average was 376.16 kgm.

The quantity of suag-kabayo cut in pasture I was 435.0 kgm.; in pasture II, 625.45 kgm.; and in pasture III, 730.45 kgm.; the average was 358.18 kgm.

Pongapong in pastures IV and V gave 623.64 kgm. and 125.0 kgm., respectively; the average weight from each pasture was 149.73 kgm.

The amount of sambong-sambongan cut from pastures IV and V was 394.55 kgm. and 194.0 kgm., respectively. The average amount cut from each pasture during the year was 117.71 kgm.

Palis in pastures IV and V, where it was a major weed, gave 358.53 kgm. in pasture IV and 105.45 kgm. in pasture V. The average weight collected from each pasture during the year was 92.80 kgm.

The weights of payang-payang lalake collected from pastures III to V were as follows: in pasture III, 147.73 kgm.; in pasture IV, 124.09 kgm.; and in pasture V, 151.76 kgm. The average weight cut from each pasture was 84.72 kgm.

In pastures IV and V, the weights of maguilic were 206.36 kgm. and 55.0 kgm. respectively; the average was 52.27 kgm.

Balatong-aso like palis was a major weed only in pastures IV and V. The weight of the weed collected from each pasture during the year was 80.44 kgm. in pasture IV and 98.64 kgm., in pasture V; the average weight cut from each pasture during the year was 35.82 kgm.

The miscellaneous weeds cut in pasture I weighed 181.38 kgm.; in pasture II, 66.36 kgm.; in pasture III, 215.91 kgm.; in pasture IV, 891.15 kgm.; and in pasture V, 513.61 kgm. The average amount cut from each pasture during the year was 373.68 kgm.

Except in hillside pasture I, the major weeds which gave the heaviest weights in the first cutting did not do the same in the succeeding cuttings. Apparently after the first cutting, *Flemingia* and *Blumea* sp. actually predominated in all of the pasture lots except in hillside pastures I and II, and in those which were cut only once, namely, plain pastures II and III.

Time needed to cut the weeds

Hillside pastures. In pasture I, 9 hours were needed to cut lantana; in pasture II, 11 hours and 30 minutes; in pasture III, 20 hours and 10 minutes; in pasture IV, 27 hours; and in pasture V, 4 hours and 50 minutes. The average time necessary to cut this weed per hectare during the year was 34 hours and 30 minutes.

Cutting payang-payang babae in pasture I required 31 hours and 30 minutes. The same weed in pasture II took 72 hours and 40 minutes; in pasture III, 34 hours and 30 minutes; in pasture IV, 37 hours; and in pasture V, 48 hours and 30 minutes. The average time needed to collect this weed from each pasture during the year was 44 hours and 56 minutes.

The total number of hours needed to cut barak in pasture I was 46 hours and 40 minutes; in pasture II, 1 hour and 30 minutes; in pasture III, 22 hours and 20 minutes; in pasture IV, 26 hours; and in pasture V, 1 hour and 45 minutes. The average time required to remove this weed in each pasture was 19 hours and 39 minutes.

For cutting guava in pasture I, 13 hours and 40 minutes were required; in pasture II, 7 hours and 10 minutes; in pasture III, 14 hours; in pasture IV, 14 hours and 10 minutes; and in pasture V, 47 hours and 34 minutes. The average time consumed in removing this weed from each pasture was 19 hours and 19 minutes.

Sambong in pasture I required 22 hours and 50 minutes; in pasture II, 9 hours; in pasture III, 42 hours and 50 minutes; in pasture IV, 9 hours and 50 minutes; and in pasture V, 9 hours and 30 minutes. The average time spent in cutting it in each pasture during the year was 18 hours and 48 minutes.

From pasture I, it required 35 hours to remove suag-kabayo, from pasture II, 6 hours; from pasture III, 32 hours and 2 minutes; and from pasture IV, 17 hours and 50 minutes. To cut this weed from each pasture during the year, the average time was 18 hours and 10 minutes.

Cutting palis in pasture II took 24 hours and 10 minutes; in pasture III, 9 hours and 30 minutes; in pasture IV, 5 hours and 30 minutes; and in pasture V, 24 hours and 35 minutes. The average time in each pasture during the year was 12 hours and 47 minutes.

Pongapong was cut in 3 hours in pasture I, 8 hours and 30 minutes in pasture II, 4 hours and 20 minutes in pasture IV, and 1 hour and 20 minutes in pasture V. Thus, the average time consumed in cutting this weed in each lot during the year was 3 hours and 26 minutes.

In pasture I, it took 6 hours and 20 minutes to cut payang-payang lalake; in pasture II, 2 hours and 10 minutes; in pasture III, 7 hours and 10 minutes; and in pasture IV, 8 hours and 30 minutes. The average time to cut it in each pasture during the year was 4 hours and 46 minutes.

Maguilic, which was present as a major weed only in pastures III and V, was cut in 1 hour and 3 hours and 20 minutes, respectively; the average time for each lot was 52 minutes.

Cutting weeds under the miscellaneous group took 25 hours and 10 minutes in pasture I, 48 hours and 40 minutes in pasture II, 40 hours and 10 minutes in pasture III, 15 hours in pasture IV, and 32 hours in pasture V; the average time consumed in each lot was 32 hours and 18 minutes.

Pastures on the plain. In pasture I, cutting sambong took 6 hours and 50 minutes; in pasture II, 5 hours and 50 minutes; in pasture III, 1 hour and 20 minutes; in pasture IV, 74 hours and 30 minutes; and in pasture V, 36 hours and 5 minutes. The average time to cut this weed in each pasture during the year was 24 hours and 55 minutes.

Cutting guava in pasture I required 5 hours and 30 minutes; in pasture III, 13 hours and 20 minutes; in pasture IV, 25 hours and 20 minutes; and in pasture V, 49 hours and 47 minutes; the average time in each pasture was 18 hours and 24 minutes.

Payang-payang babae in pasture I required 6 hours and 5 minutes to cut; in pasture II, 2 hours; in pasture III, 12 hours and

50 minutes; in pasture IV, 21 hours and 20 minutes; and in pasture V, 25 hours. The average time was 13 hours and 27 minutes in each lot.

To cut suag-kabayo in pasture I consumed 20 hours and 50 minutes; in pasture II, 25 hours and 40 minutes; and in pasture III, 19 hours and 20 minutes. During the entire period, cutting it required, on the average, 13 hours and 10 minutes in each lot.

In pastures IV and V, where pongapong was found as a major weed, the time consumed to cut it was 5 hours and 20 minutes and 1 hour and 30 minutes, respectively; the average time was 1 hour and 22 minutes.

Like pongapong, sambong-sambongan was present as a major weed in pastures IV and V only. The time required for cutting it in these pastures was 17 hours and 30 minutes and 13 hours and 30 minutes, respectively. The average time to cut it from each pasture during the year was 6 hours and 1 minute.

Palis was a major weed in pastures IV and V only. The time required to cut it was 15 hours and 20 minutes in pasture IV, and 4 hours and 20 minutes in pasture V; the average time was 3 hours and 56 minutes in each pasture during the year.

Cutting payang-payang lalake in pasture III took 5 hours; in pasture IV, 6 hours; and in pasture V, 11 hours and 30 minutes. The average time to cut it in each pasture was 4 hours and 30 minutes.

Maguilic was a major weed in pastures IV and V. The time consumed for cutting it in pasture IV was 1 hour and 20 minutes, and in pasture V, 2 hours and 15 minutes; the average was 43 minutes.

Balatong-aso was cut in pasture IV in 4 hours and 20 minutes, and in pasture V, 5 hours and 30 minutes; the average time was 1 hour and 58 minutes.

The time spent in cutting the miscellaneous species of weeds in the different pastures varied. Those in pasture I required 20 hours and 32 minutes; in pasture II, 9 hours; in pasture III, 12 hours and 30 minutes; in pasture IV, 23 hours and 40 minutes; and in pasture V, 22 hours and 20 minutes. The average time necessary to cut them in each pasture was 17 hours and 36 minutes.

Cost of cutting

Hillside pastures. Lantana being the heaviest weed in the hillside pastures was the most expensive. Cutting this weed in pasture I cost ₱0.90; in pasture II, ₱11.15; in pasture III, ₱2.07; in pasture IV, ₱2.70; and in pasture V, ₱0.48. The average cost for each pasture during the year was ₱3.45.

To remove payang-payang babae from pasture I cost ₱3.14; from pasture II, ₱7.27; from pasture III, ₱3.45; from pasture IV, ₱3.70; and from pasture V, ₱4.89. The average cost for each pasture during the year was ₱4.49.

In pasture I, cutting barak cost ₱4.60. The same weed in pasture II cost ₱0.15, and in pasture III, ₱2.23. In pasture IV, the cost of cutting this weed was ₱2.60 and in pasture V, ₱0.18. The average cost of cutting this weed in each pasture during the year was ₱1.96.

In the different pastures, the cost of cutting guava varied. In pasture I, it cost ₱1.37; in pasture II, ₱0.72; in pasture III, ₱1.40; in pasture IV, ₱1.42; and in pasture V, ₱4.76. To cut this weed in each pasture during the year, the average cost was ₱1.93.

The cutting of sambong in pasture I was ₱2.20; in pasture II, ₱0.90; in pasture III, ₱4.29; in pasture IV, ₱0.98; and in pasture V, ₱0.95. In each pasture the average cost of cutting during the year was ₱1.88.

To cut suag-kabayo in pasture I cost ₱3.50; in pasture II, ₱0.60; in pasture III, ₱3.20; and in pasture IV, ₱1.79; the average cost for each pasture during the year was ₱1.82.

The cost of cutting palis in pasture II was ₱2.41 and in pasture III, ₱0.95. The same weed in pasture IV cost ₱0.55 and in pasture V, ₱2.45; the average for each pasture during the year was ₱1.28.

To cut pongapong in pasture I, the cost was ₱0.30; in pasture II, ₱0.85; in pasture IV, ₱0.43; and in pasture V, ₱0.13. The average cost for each pasture during the whole period was ₱0.34.

The cost of cutting payang-payang lalake in pasture I was ₱0.63; in pasture II, ₱0.22; in pasture III, ₱0.72; and in pasture IV, ₱0.85. To cut it in each pasture during the year, the average cost was ₱0.48.

For cutting maguilic in pasture III, where it was a major weed, the cost was ₱0.10 and in pasture V, ₱0.33; the average cost for each pasture was ₱0.09.

To cut the miscellaneous weeds in the different pastures, the cost was as follows: in pasture I, ₱2.47; in pasture II, ₱4.87; in pasture III, ₱4.02; in pasture IV, ₱1.50; and in pasture V, ₱3.25. The average cost in each pasture during the year was ₱3.23.

Pastures on the plain. The heaviest weed in the plain pastures was sambong, and being the most abundant, it was also the most expensive to cut. In pasture I, the cost of cutting it was ₱0.68; in pasture II, ₱.58; and in pasture III, ₱0.13. The highest cost (₱7.45) of cutting the same weed was in pasture IV. In pasture V, it cost ₱3.61. The average cost of cutting this weed in each pasture during the year was ₱2.49.

The cost of cutting guava in pasture I was ₱0.55; in pasture III, ₱1.33; in pasture IV, ₱2.53. The highest cost, ₱4.97, was in pasture V. The average cost of cutting the same weed in each pasture during the year was ₱1.83.

To cut payang-payang babae in pasture I, the cost was ₱0.61; in pasture II, ₱0.20; in pasture III, ₱1.28; in pasture IV, ₱2.14; and in pasture V, ₱2.50. The average cost for each pasture during the year was ₱1.35.

Suag-kabayo was a major weed in pastures I to III; the cost of removing it was ₱2.08 in pasture I, ₱2.57 in pasture II, and ₱1.93 in pasture III. The average for each pasture was ₱1.31.

Pongapong was cut at a cost of ₱0.53 in pasture IV and ₱0.15 in pasture V; the average for each pasture during the year was ₱0.14.

Sambong-sambongan was also a major weed only in pastures IV and V, and the expenses incurred in cutting it was ₱1.75 in pasture IV and ₱1.35 in pasture V; the average was ₱0.60 for each pasture during the year.

Palis in pastures IV and V was a major weed, and the cost of cutting it in each pasture was ₱1.53 and ₱0.43, respectively. The average cost of removing it from each pasture during the year was ₱0.39.

Payang-payang lalake was one of the least abundant but most persistent weeds in all pastures. The cost of cutting it was ₱0.50 in pasture III, ₱0.60 in pasture IV, and ₱1.15 in pasture V. The average cost of cutting it in each pasture during the year was ₱0.45.

Maguilic as a major weed was found only in pastures IV and V, and the cost of cutting it was ₱0.13 and ₱0.23, respectively. The average cost for each pasture was ₱0.07.

For removing balatong-aso in pasture IV, the cost was ₱0.43 and in pasture V, ₱0.55. The average cost of cutting this weed was ₱0.20 in each pasture during the year.

To cut the miscellaneous weeds in the different pastures in the plain cost ₱2.05 in pasture I, ₱0.90 in pasture II, ₱1.25 in pasture III, ₱2.36 in pasture IV, and ₱2.34 in pasture V; the average was ₱1.78 during the year.

SUMMARY AND CONCLUSION

1. The various species of weeds infesting pastures at the College of Agriculture, Los Baños, Laguna, and the cost of removing them are reported in this paper.

2. Based on the first cutting, the major weeds found in the hillside pastures were: lantana (*Lantana camara* Linn.), barak [*Curcuma zedoaria* (Berg.) Rosc.], payang-payang babae [*Flemingia strobilifera* (Linn.) R. Br.], suag-kabayo (*Hyptis suaveolens* Poir.), guava (*Psidium guajava* Linn.), pongapong [*Amorphophallus campanulatus* (Roxb.) Blm.], sambong [*Blumea balsamifera* (Linn.) DC.], palis (*Callicarpa cana* Linn.), maguilic (*Premna cumingiana* Sch.), kambali (*Hyptis capitata* Jacq.), payang-payang lalake [*Desmodium pulchellum* (Linn.) Benth.], aroma [*Acacia farnesiana* (Linn.) Willd.], and balatong-aso (*Cassia tora* Linn.). In the plain pastures, the major weeds were: sambong, guava, suag-kabayo, pongapong, sambong-sambongan [*Blumea lacera* (Burm. f.) DC.], payang-payang babae, maguilic, payang-payang lalake, palis, and balatong-aso. Balatong-aso appeared as a major weed at the second cutting in both hillside and plain pastures.

3. Species of plants classified under the miscellaneous group were similar on both hillside and plain. They were the following: pandacake (*Tabernaemontana pandacaqui* Poir.), kasopangil (*Clerodendron intermedium* Cham.), colotcolotan (*Triumfetta* sp.), escobang-bilog (*Sida retusa* Linn.), dilang-baca (*Elephantopus scaber Linn.*), marcela (*Ageratum conyzoides* Linn.), mankit [*Desmodium gangeticum* (Linn.) DC.], sili (*Capsicum frutescens* Linn.), uray (*Amaranthus spinosus* Linn.), bulak-manok [*Vernonia patula* (Dry.) Merr.], dilao (*Curcuma longa* Linn.), and hangod [*Stachytarpheta jamaicensis* (Linn.) Vahl].

4. In all the hillside pastures except pasture IV, which was cut only twice, it was necessary to cut the weeds three times during the year. In the plain, the weeds were cut only once in two pastures, twice in one pasture, and thrice in two pastures.

5. In the hillside pastures, the first cutting was from May 29 to September 26, 1936, the second, from September 29, 1936, to January 29, 1937, and the third, from February 4, 1937, to May 17, 1937.

In the plain pastures, the first cutting was from July 14 to September 28, 1936, the second from December 15 to 21, 1936, and the third from March 23 to May 17, 1937.

6. The average height of the major weeds in the hillside pastures was lantana, 154.0 cm.; palis, 73.0 cm.; suag-kabayo, 72.0 cm.; pongapong, 71.5 cm.; payang-payang lalake, 71.0 cm.; guava, 69.8 cm.; payang-payang babae, 62.4 cm.; sambong, 59.4 cm.; and barak, 48.1 cm. That of the major weeds in the plain pastures was: maguilic, 128.0 cm.; suag-kabayo. 74.7 cm.; sambong, 72.0 cm.; guava, 67.0 cm.; payang-payang lalake, 63.3 cm.; sambong-sambongan, 62.5 cm.; payang-payang babae, 61.8 cm.; palis, 60.5 cm.; pongapong, 59.0 cm.; and balatong-aso, 51.0 cm.

7. The weight of the different species of major weeds cut from the hillside pastures was: lantana, 2,358.17 kgm.; payang-payang babae, 1,390.58 kgm.; barak, 1,021.87 kgm.; guava, 541.55 kgm.; sambong, 497.18 kgm.; suag-kabayo, 372.91 kgm.; palis, 305.79 kgm.; pongapong, 222.90 kgm.; payang-payang lalake, 101.38 kgm.; and maguilic, 68.09 kgm. Of those in the plain pastures the weight was: sambong, 1,379.25 kgm.; guava, 656.89 kgm.; payang-payang babae, 376.16 kgm.; suag-kabayo, 358.18 kgm.; pongapong, 149.73 kgm.; sambong-sambongan, 117.71 kgm.; palis, 92.80 kgm.; payang-payang, lalake, 84.72 kgm.; maguilic, 52.27 kgm.; and balatong-aso, 35.82 kgm.

8. The average time required to cut each of the major weeds in the hillside pastures during the year was as follows: payang-payang babae, 44 hours and 56 minutes; lantana, 34 hours and 30 minutes; barak, 19 hours and 39 minutes; guava, 19 hours and 19 minutes; sambong, 18 hours and 48 minutes; suag-kabayo, 18 hours and 10 minutes; palis, 12 hours and 47 minutes; payang-payang lalake, 4 hours and 46 minutes; pongapong, 3 hours and 26 minutes; and maguilic, 52 minutes. The time in the plain pastures was: sambong, 24 hours and 55 minutes; guava, 18 hours and 24 minutes; payang-payang babae, 13 hours and 27 minutes; suag-kabayo, 13 hours and 10 minutes; sambong-sambongan, 6 hours and 1 minute; payang-payang lalake, 4 hours and 30 minutes; palis, 3 hours and 56 minutes; balatong-aso, 1 hour and 58 minutes; pongapong, 1 hour and 22 minutes; and maguilic, 43 minutes.

9. The length of time required for cutting the weeds is not always directly proportional to the weight of the weeds because some are easier to cut than others.

10. To cut the weeds in the hillside pastures, the average cost per hectare was; payang-payang babae, ₱4.49; lantana, ₱3.45; barak, ₱1.96; guava, ₱1.93; sambong, ₱1.88; suag-kabayo, ₱1.82; palis, ₱1.27; payang-payang lalake, ₱0.48; pongapong, ₱0.34; maguilic, ₱0.08; and

the miscellaneous weeds, ₱3.23. The cost on the plain was: sambong, ₱2.49; guava, ₱1.83; payang-payang babae, ₱1.35; suag-kabayo, ₱1.31; sambong-sambongan, ₱0.60; payang-payang lalake, ₱0.45; palis, ₱0.39; balatong-aso, ₱0.20; pongapong, ₱0.14; maguilic, ₱0.07, and the miscellaneous weeds, ₱1.78.

11. The total cost of cutting the weeds in the hillside pastures under Los Baños conditions was, on the average, ₱20.94 per hectare during the year and in the pastures on the plain, ₱10.61.

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TABLE 1

Summary of the height, weight, time required, and cost of cutting of all the weeds in the hillside pastures at different periods of the year

WEEDS	AVERAGE HEIGHT	WEIGHT	TIME		COST
	cm.	*kgm.*	*hrs.*	*min.*	*pesos*
Lantana	154.0	2,358.17	34	30	3.45
Payang-payang babae	62.4	1,390.58	44	56	4.49
Barak	48.1	1,021.87	19	39	1.96
Guava	69.8	541.55	19	19	1.93
Sambong	59.4	497.18	18	48	1.88
Suag-kabayo	72.0	372.91	18	10	1.82
Palis	73.0	305.79	12	47	1.28
Pongapong	71.5	222.90	3	26	0.34
Payang-payang lalake	71.0	101.38	4	46	0.48
Maguilic	87.0	68.09	—	52	0.09
Miscellaneous	—	485.25	32	18	3.23
Total		7,365.67	209	31	20.94

TABLE 2

Summary of the height, weight, time required, and cost of cutting of all the weeds in pastures on the plain at different periods of the year

WEEDS	AVERAGE HEIGHT	WEIGHT	TIME		COST
	cm.	*kgm.*	*hrs.*	*min.*	*pesos*
Sambong	72.0	1,379.35	24	55	2.49
Guava	67.0	656.89	18	24	1.83
Payang-payang babae	61.8	376.16	13	27	1.35
Suag-kabayo	74.7	358.18	13	10	1.31
Pongapong	59.0	149.73	1	22	0.14
Sambong-sambongan	62.5	117.71	6	1	0.60
Palis	60.5	92.80	3	56	0.39
Payang-payang lalake	63.3	84.72	4	30	0.45
Maguilic	128.0	52.27	—	43	0.07
Balatong-aso	51.0	35.82	1	58	0.20
Miscellaneous	—	373.68	17	56	1.78
Total	—	3,677.31	106	2	10.61

COLLEGE AND ALUMNI NOTES

Dean and Mrs. L. B. Uichanco were hosts to the faculty of the College at a luncheon at Molawin Hall on September 24. President and Mrs. B. M. Gonzalez honored the occasion with their presence.

A concert under the joint sponsorship of the Los Baños Y.M.C.A. committee on management and the 1939 Loyalty Day committee on finance was presented at Baker Hall on the evening of September 23. The participants were Luis Valencia, violinist, Fely Morales, coloratura soprano, and Bernardino Custodio, accompanist.

A party of College professors including Dr. F. M. Sacay, Professor V. B. Aragon, Dr. P. N. Mabbun, and Professor J. E. Velmonte spent September 30 at the Buenavista Estate, San Ildefonso, Bulacan, to observe the work now being undertaken by the Rural Progress Administration under Mr. José Sanvictores.

Acting U. S. High Commissioner Jones was the principal speaker at the Loyalty Day ceremonies which also celebrated the thirtieth anniversary of the founding of the College. Before a large crowd which gathered at Baker Hall, Commissioner Jones paid tribute to the high idealism of Los Baños and the development through the years of worthy traditions since Dean Copeland carved the site of the College from the wilds of Mt. Maquiling. On October 10, 1918, he said, "you witnessed the entire College entraining for Manila to offer their services in toto, from janitor to Dean, to aid the sovereign at war." But, he added, "None of those traditions surpasses that which we celebrate today." Speaking of the disillusionment of the people of the world today over the nations again at war he said, "I ask you to turn from disillusionment to rational hope. In institutions like Los Baños there is hope for a better world. It is campuses such as these which offer an antidote to the too prevalent feeling that social idealism is laudable but futile. We must keep on working for the things which we have always worked for, which we have always believed in."

A reception and dance in honor of President and Mrs. B. M. Gonzalez and Dean and Mrs. L. B. Uichanco offered by the students of the College closed the Loyalty Day and thirtieth anniversary celebration on October 10. The University Women's Club made the affair memorable by bringing from Manila no less than one hundred coeds, the cream of the University.

Winners in the 1939 Loyalty Day literary contest for students of the College of Agriculture and the School of Forestry, sponsored by the representatives of the Board of Management of *The Philippine Collegian,* were as follows:

Solomon Cabrera	Essay
Martin Jarmin	Short story
Arnulfo Yñiguez	English poem
Enrique Octavio	Tagalog poem

For the best participation in the 1939 Loyalty Day parade the judges awarded first place to the student body of the College, second, Department of Animal Husbandry, honorable mention, Department of Agronomy and special mention, the Los Baños Economic garden.

STUDIES ON THE PHYSICAL QUALITIES OF THE HEN'S EGG: VII. VARIABILITY OF THE PHYSICAL QUALITIES OF NEW-LAID EGGS PRODUCED IN DIFFERENT LAYING PERIODS[1]

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It is a well-known fact that pullets when in the early stages of laying produce small eggs, but these gradually increase to normal size as laying progresses. Bennion and Warren (1933), however, reported that a gradual decrease in size of each successive egg in the clutch occurred, and the longer the clutch, the greater the decrease from the first to the last egg, but the smaller the decrease of each egg within the clutch. They further reported that when the egg size was on the increase among pullets, there was a smaller decrease with the successive eggs of a clutch than when the bird had reached its maximum egg size.

With these variations in the size of eggs, what changes, if any, take place in the different parts of these eggs? As no report along this line is available at present, this study was made to determine what changes take place in the physical qualities of new-laid eggs produced at different laying periods and to find out which of the constituents of the eggs influence these variations. This study was conducted in the Poultry Laboratory of the Department of Animal Husbandry from January to August, 1937.

PLAN OF THE STUDY

Eggs from a commercial flock of mated Los Baños Cantonese pullets which were just starting to lay were used in this study. To produce these eggs, the College standard ration for layers was used.[2] Thirteen groups of eggs were studied. These were the first, fifth,

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[1] The data presented in this paper were taken from the thesis presented by the junior author for graduation, 1938, with the degree of Bachelor of Science in Agriculture from the College of Agriculture, University of the Philippines; Experiment Station contribution No. 1325.

[2] The standard laying ration of the College consists of one part grain composed of equal parts of palay and corn and one part of mash composed of four parts, by weight, of rice bran, three copra meal, one corn meal, and two fish meal.

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tenth, fifteenth, twentieth, twenty-fifth, thirtieth, thirty-fifth, fortieth, forty-fifth, fiftieth, fifty-fifth, and sixtieth eggs.

All eggs were examined within twenty-four hours after they had been laid. The characters studied were the following: (*a*) texture and color of the shell, (*b*) weight of the egg, (*c*) angle of inclination, (*d*) volume of the egg, (*e*) weight of yolk, (*f*) diameter and height of yolk, (*g*) strength of yolk, (*h*) weight and thickness of shell, (*i*) amount of albumen, (*j*) color of albumen, and (*k*) size of germ. The methods used in studying these characters were similar to those described by Fronda and Clemente (1934).

To determine the relative proportion of each constituent in different clutches, the first fourteen successive clutches from different birds were studied and the average was determined. The proportion of shell, yolk, and albumen, based on the weight of the egg, was determined.

To determine the influence of the position of the egg in the clutch on the weight and the percentages of its parts, ten clutches of eggs were studied. The eggs in different positions in the clutch were weighed. The different parts were separated and weighed individually. The proportion of each part, based on the weight of the eggs, was determined.

RESULTS AND DISCUSSION

External appearance. It may be noted in table 1 that there were apparent variations in the texture of the egg shell. High percentages of poor shells were recorded among the eggs that were laid later and high percentages of good shells among those laid earlier. The tendency, however, was not very consistent. Eggs with medium textured shells apparently predominated and represented from 40 to 77 per cent of the eggs throughout the laying periods.

It may also be seen from table 1 that generally the Los Baños Cantonese eggs are mostly light brown and tinted. The position of the egg in the laying period of the hen had apparently no influence on the color of the shell. The distribution of colors of the egg shell in this study followed the same tendency as that reported by Fronda and Juan (1937).

The air cell. The dimensions of the air cell and the air cell index are presented in table 2. It may be noted that there was a general tendency for the diameter of the air cell to increase as the laying progressed. Exceptions were, however, observed. The differences that may be noted may be attributed to the differences in the porosity of the egg shells. These degrees of porosity were found to have a close relation to the rates of shrinkage of the egg (Almquist, 1933). The height of the air cell did not vary as much as the diameter. This may be due to the fact that the air cell was not confined to a fixed part of the egg.

The dimensions of the air cells observed in this study are much lower than those found by previous investigators (Fronda and Clemente, 1934; Fronda, Clemente, and Basio, 1935; and Fronda and Juan, 1937). These differences may be due to the age of the birds that laid these eggs and to the weather conditions.

By reference also to table 2, it may be seen that the air cell index tended to increase from the first egg to the fifteenth, whence a decrease was observed up to the thirty-fifth, after which an increase was recorded up to the forty-fifth egg. The maximum air cell index found in this study agrees with those reported by Fronda and Clemente (1934), and Fronda and Juan (1937).

Weight of eggs. By reference to table 3, it may be noted that the mean weight of the eggs increased steadily from the first to the sixtieth. The first eggs were the lightest with a mean weight of only 33.98 ± 0.279 grams, while the sixtieth were the heaviest with a mean weight of 46.04 ± 0.521 grams. These results were expected. Uichanco (1933) reported that the pullets at ten months produced eggs that weighed 42.1 ± 0.0975 grams. Dañgilan (1926) reported that the average weights of the first five eggs were as follows: the first eggs averaged 32.15 grams; the second, 35.75 grams; the third, 32.29 grams; the fourth, 40.79 grams; and the fifth, 40.21 grams.

Volume of the eggs. Again by reference to table 3, it may be observed that the volume of the eggs followed the same tendency as that of the weight. The minimum volume was recorded in the first egg, 31.37 ± 0.419 cc., and the maximum in the sixtieth egg, 43.51 ± 0.313 cc. These corroborate the tendency observed by Fronda and Clemente (1934), and Fronda and Juan (1937).

Specific gravity of the eggs. It will be noted also in table 3 that the specific gravity of the eggs in the different positions varied from 1.010 ± 0.0021 in the first egg to 1.074 ± 0.0029 in the tenth. The variations in the specific gravity after the tenth egg were only slight. The specific gravity reported by Fronda and Clemente (1934), and Fronda and Juan (1937) favorably compares with that reported in this study. Pearl and Curtis (1916), studying the specific gravity of dwarf and normal eggs, found that the mean for 180 normal eggs was 1.0288. The difference between this figure and those aforementioned is considered significant. Variations in the thickness of the shell of the eggs might have caused such differences.

Diameter and the height of yolk. The data on these characters are presented in table 4. It may be seen from this table that the diameter of yolks of the eggs observed varied from 3.48 ± 0.019 centimeters in the first egg to 4.02 ± 0.051 centimeters in the sixtieth. It may be seen further that there was a general tendency for the diameter of the yolk to increase as the laying progressed.

The height of the yolk also varied from 1.52 ± 0.012 centimeters in the first egg to 1.71 ± 0.011 centimeters in the sixtieth. It can be seen from this table that it followed the same tendency as its diameter. From the first to the tenth egg, the height was observed to be almost uniform, but after this, an increase was noted and maintained, with slight variations, up to the sixtieth egg.

Fronda and Clemente (1934) observed that the diameter of the yolk varied from 3.56 to 4.55 centimeters, and the height, from 1.54 to 2.21 centimeters. Fronda and Juan (1937) reported that the diameter of the yolk varied from 3.832 ± 0.004 centimeters to 3.968 ± 0.005 centimeters, and the height, from 1.785 ± 0.003 to 1.821 ± 0.002 centimeters. The yolk dimensions herein reported are lower than those found by the above investigators, although the maximum in this paper favorably compares with that reported by Fronda and Juan (1937).

The yolk index. The best criterion of egg quality determination is the yolk index (Sharp and Powell, 1930). In table 4, it can be seen that the variations in the yolk indices were very slight and there seemed to be no relation between this character and the position of the egg in the laying schedule of the bird. The means ranged from 0.43 ± 0.003 in the fiftieth egg to 0.44 ± 0.003 in the thirty-fifth. The yolk indices observed in this study are slightly lower than those reported by Fronda and Clemente (1934), and by Fronda and Juan (1937).

Weight of yolk. Table 5 shows the weight and strength of the yolk and its relation to the total weight of the egg. The mean weight of the yolk varied from 10.32 ± 0.129 grams in the first egg to 14.94 ± 0.283 grams in the sixtieth. From the first egg, the weight of the yolk, with slight variations increased steadily.

Fronda and Juan (1937) observed that the mean weights of the yolk varied from 12.712 ± 0.041 grams to 13.795 ± 0.047 grams. The maximum reported by these investigators was less than that observed in this study. Pearl and Curtis (1916) found that the weight of the yolk of eggs which had a mean weight of 52.92 ± 0.06 grams was 15.77 ± 0.02 grams. This is much higher than those mentioned above. These differences may be explained by the fact that larger eggs have larger yolks (Pearl and Curtis, 1916).

It appears from the data in table 5 that the heavier the egg the heavier was the yolk in proportion to the total egg weight. The variations in the ratio of yolk compared with the total weight of the eggs were, however, slight. Fronda and Juan (1937) found the average ratio of the yolk to the total egg weight to be 31.41 per cent. Langworthy (1917) reported that the yolk constituted 32 per cent of the total weight of the hen's egg. He further stated that the proportion varies with different breeds. In general, it is greater in those breeds best suited for fattening than in others.

Strength of yolk. The strength of the yolk is considered one of the indices of egg quality. Variations in the strength of the yolk of the eggs in different laying periods may be noted in the data given in table 5. The weakest yolk as well as the most variable in strength was observed in the sixtieth egg, with a mean of 21.77 ± 1.620 times, and a coefficient of variation of 34.88 per cent. The strongest yolk which was in thirty-fifth egg, was the least variable and had a mean of 42.14 ± 0.115 times, with a coefficient of variation of 17.98 per cent. Among the characters studied, the strength of the yolk was observed to be the most variable. The strongest yolk reported by Fronda and Juan (1937) could be transferred from palm to palm thirty-seven times which is within the range reported in this paper. The strength of the yolk, however, did not follow a definite trend as did other characters.

Weight of thick and thin albumen. The weight and volume of the thick and the thin albumen are presented in table 6. It may be observed that the weight of the thick albumen varied. From the first to the twentieth egg, a gradual increase was recorded; after this period although the weight of the thick albumen was variable, a tendency to increase is noticeable up to the sixtieth egg. It is apparent that the weight of the thick albumen was slightly influenced by the position of the eggs in the laying period of a pullet.

From the same table, the amount of thin albumen may be observed to be much smaller than the thick. The variations in weight of the thin albumen followed the same trend as those of the thick, but the tendency to increase was more marked in the former.

When the whole albumen was considered, a gradual increase in weight from the first egg to the sixtieth was observed. This tendency to increase is expected since the weight of each of the constituents of the egg is highly correlated with the size of the egg. Fronda and Juan (1937) gave the range of weights of the thick albumen to be from 8.037 to 9.660 grams. The weights of the thin albumen reported in this paper were decidedly higher than those by Fronda and Juan (1937). The weight of the whole albumen compared with the weight of the egg was observed to be fairly uniform from the first to the sixtieth egg. Langworthy (1917) reported that the albumen constituted 58 per cent of the total egg weight. Fronda and Juan (1937) found the albumen of the eggs studied to vary from 52.57 to 54.86 per cent. These figures are much lower than those reported in this paper.

Angle of inclination. The data on the angle of inclination of new-laid eggs produced in different laying periods are given in table 7. It can be seen that the angle of inclination of the egg has a slight tendency to increase as the laying progresses, but the trend does not seem to be consistent. Fronda and Juan (1937) reported that the angle of inclination of the eggs of their flock which received the College standard laying ration had a mean of 9.753 ± 0.057 degrees. This figure favorably compares with the maximum reported in this paper. Fronda and Clemente (1934) reported, however, that the angle of inclination was 10.840 ± 0.181 degrees, which is much higher than the above figures. This difference may be due to variations in climatic conditions.

The germ. It may be seen from table 7 that the diameter of the germ varied and the variations observed in the different laying periods are not great. It may be stated that, in general, the position of the egg did not materially affect the size of the germ. The size of the germ found by Fronda and Clemente (1934) varied from 0.602 ± 0.0209 cm. to 0.696 ± 0.0168 cm. The figures found in this study are very much lower than those reported by Fronda and Clemente (1934). These marked differences may be due partly to the fact that the birds used in this study were just starting to lay, and the weather conditions were not the same.

Weight of shell. From table 8 it may be seen that there was a general tendency for the weight of the shell to increase as the laying progressed. When compared with the weight of the egg, the relation was inverse; the percentage of shell decreased as the weight of the egg increased. The weight of the shell increases as the laying progresses because the eggs have increased in size, but the increase in the weight of the shell is not so much as that of the egg. The weight of shell varied from 10.06 to 10.99 per cent of the total weight of the egg. According to Pearl and Curtis (1916), normal eggs that weighed 52.92 ± 0.06 grams had shells that weighed 5.12 ± 0.01 grams, and Fronda and Juan (1937) reported that the weight of the shell of Los Baños Cantonese eggs varied from 4.745 to 4.878 grams. The figures reported in this study are much lower than those found by the previous workers probably because the eggs used in this study were smaller than those of Fronda and Juan (1937). Langworthy (1917) reported that the shell constituted 11.00 per cent of the total weight of the egg.

Thickness of tip, middle, and butt of shell. The thickness of the shell is presented also in table 8. From this table, it can be noted that the thickness at the butt of the shell in all periods studied was fairly uniform, and these varied from 0.23 ± 0.004 mm. with a coefficient of variation of 13.11 ± 1.387 per cent to 0.25 ± 0.007 mm. with a coefficient of variation of 15.66 ± 2.054 per cent. There was a tendency, however, for the shell of the butt of the egg laid during the earlier period to be thicker than those laid later. Again, the thickness at the middle and at the tip of the shell was more or less uniform. The mean thickness at the middle varied from 0.25 ± 0.002 mm., with a coefficient of variation of 10.054 ± 0.678 per cent to 0.27 ± 0.007 mm., with a coefficient of variation of 11.67 ± 1.784 per cent; and that at the tip from 0.23 ± 0.004 mm., with a coefficient of variation of 12.43 ± 1.381 per cent to 0.27 ± 0.005 mm., with a coefficient of variation of 10.82 ± 1.531 per cent.

It can be noted from this table that in general the middle portion of the egg shell is thicker than either the butt or the tip. This result corroborates that of Fronda and Juan (1937). The thickness of the three different portions of the shell, as reported by these workers, are as follows: butt, 0.304 mm.; middle, 0.319 mm.; and tip, 0.305 mm. Holst, Almquist, and Lorenz (1932) found that of the 250 eggs they studied, the thickness of those with good shells was 0.330 mm., and those with medium and poor was 0.321 mm. The thickness of normal shells studied by Almquist and Burmester

(1934) was 0.341 mm. The figures reported in this paper are much lower than those obtained by previous workers. The differences may be due to the differences of the breeds of chickens studied.

Color of yolk. It may be seen from table 9 that there was a great variation in the color of the yolks of eggs produced in different periods. The percentage of pale yellow yolks was small throughout the period studied. It can be seen from this table that generally there were more medium yellow yolks than either deep yellow or pale yellow. The color of the yolk, however, did not follow a definite trend, and it appears that the position of the egg in the laying schedule of the bird does not influence the color of the yolk.

Color of albumen. By reference to table 10, it can be seen that albumen with a sulfur yellow color is more common than either dark sulfur or light sulfur yellow. These color variations may probably be accounted for by the irregularity in the supply of green feeds during the course of the experiment. Feeds rich in xantophyll, like green weeds and yellow corn, when fed to layers produced dark colored yolk and albumen (Almquist, 1933, and Fronda and Juan, 1937). Like the color of yolk, the color of the albumen did not appear to be influenced by the position of the egg in the laying schedule of the bird.

Relative proportion of each of the constituents of eggs in the different clutches. If the variations in the weight of the egg in different clutches are considered, it may be seen by reference to table 11 that, although the weight of the eggs varied in different clutches, it increased as the laying progressed. The weight varied from 36.001 grams in the first clutch to 45.040 grams in the fourteenth. This tendency for the weights of the eggs to increase in different clutches corroborated the findings of Bennion and Warren (1933).

Table 11 also shows the relation of each part—the shell, the yolk, and the albumen—to the total weight of the egg. From this table, it may be observed that, in general, the percentages of each part were fairly uniform, although in the yolk, upon closer examination of the data, there was a slight increase, and in the albumen, a slight decrease, as laying progressed. These variations in the ratio of the other parts did not follow the same tendency as the weight.

Effect of the position of the egg in the clutch on the weight and percentage of each part. The weight and the relative proportion of each part to the total egg weight are presented in table 12. It may be observed from this table that there were also variations in the size of the egg at different positions in the clutch. It may be noted also that the weight of the egg did not follow a definite tendency. With the exception of the seventh, the position of the egg in the clutch had no apparent influence on the size of the egg.

Taking the ratio of each part to the total weight of the egg, a tendency to decrease may be seen in the percentage of the yolk and the shell. In the amount of albumen, however, a slight increase was apparent. From these figures, it can be stated that the eggs laid later in the clutch had less shell and yolk but more albumen than those laid earlier.

These percentages of the parts of the egg in different positions in the clutch were just the reverse of those followed by the same parts of the egg in different clutches during the laying period; that is, an increase was observed in the percentages of the yolk and the shell in different clutches, whereas a decrease of the ratio of these parts to the total weight of the egg was found in different positions in the clutch. In the albumen, a decrease was noted in different clutches, whereas an increase was observed in different positions in the clutch.

This difference was an indication that the reproductive organs of the pullets functioned better during the earlier period where there were rest intervals than when there was a continuous laying of eggs. This tendency corroborates the findings of Pearl and Curtis (1916).

SUMMARY AND CONCLUSIONS

1. Eggs laid earlier in the laying period had better shells than those laid later.

2. The position of the egg in the laying period of the hen had apparently no influence on the color of the shell.

3. There was a general tendency for the diameter of the air cell to increase as the laying progressed. The height of the air cell did not follow the same trend.

4. There was no definite tendency followed by the air cell index of the eggs laid in the different laying periods.

5. Eggs produced in the later laying periods were larger than those laid in the earlier. The volume of the eggs followed the same tendency as the weight.

6. The specific gravity increased from the first to the tenth egg, but after this, variations in the specific gravity were only slight.

7. The diameter and height of the yolk tended to increase as laying progressed.

8. There seemed to be no relation between the yolk index and the position of the egg in the laying schedule of the bird.

9. A gradual increase in the weight of the yolk was noted in the eggs produced as the laying progressed.

10. It was observed that the heavier the egg, the heavier the yolk in proportion to the total egg weight.

11. The position of the egg in the laying schedule of a hen apparently did not influence the strength of the yolk. The weakest yolk was, however, observed in the sixtieth egg.

12. Both the thick and the thin albumen tended to increase in weight as laying progressed.

13. A gradual increase in weight of the whole albumen was observed from the first egg to the sixtieth, but compared with the weight of the egg, the proportion remained fairly uniform as the laying progressed.

14. A slight but steady increase was noted in the angle of inclination of eggs as the period of laying advanced.

15. The position of the egg in the laying schedule of a hen did not materially affect the size of the germ.

16. The weight of the shell was observed to increase as laying progressed, but the ratio of the shell to the weight of the egg tended to decrease as the latter increased.

17. There was a tendency for the shell of the butt of the eggs laid earlier in the period to be thicker than that of those laid later.

18. The position of the egg in the laying schedule of a bird apparently does not influence the color of either the yolk or the albumen.

19. There was a gradual increase in the weight of eggs produced in the different clutches as laying progressed. A similar tendency was noted in the percentages of yolk and shell, but in the case of the albumen, there was a decrease noted.

20. The weight of the eggs in different positions in the clutch did not follow a definite tendency. The percentage of the yolk and shell tended to decrease, but a slight increase was noted in the percentage of the albumen.

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TABLE 1

Texture and color of the egg shell of new-laid eggs

ORDER THE EGGS WERE LAID	TEXTURE			COLOR			
	Good	Medium	Poor	Brown	Light brown	Tinted	White
	per cent	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*
1st	23.53	58.82	17.65	7.81	58.82	29.41	3.93
5th	22.22	61.11	16.67	11.11	61.11	22.22	5.56
10th	15.39	76.92	7.69	0	69.23	30.77	0
15th	29.41	52.94	17.65	0	64.71	29.41	5.88
20th	21.05	63.16	15.79	15.79	52.63	21.05	10.53
25th	23.81	52.38	23.81	14.29	47.62	33.33	4.76
30th	15.79	47.37	36.84	5.26	63.16	31.58	0
35th	28.57	57.14	14.29	4.76	71.43	23.81	0
40th	33.33	40.00	26.67	13.33	46.67	40.00	0
45th	18.18	63.64	18.18	9.09	63.64	18.18	9.09
50th	11.76	70.59	17.65	5.88	64.71	17.65	11.76
60th	14.29	57.14	28.57	0	78.57	14.29	7.14
55th	10.00	60.00	30.00	0	50.00	40.00	10.00

TABLE 2

Mean dimensions of the air cells and the air cell index of new-laid eggs

ORDER THE EGGS WERE LAID	DIAMETER OF AIR CELL	HEIGHT OF AIR CELL	AIR CELL INDEX
	cm.	*cm.*	*cm.*
1st	1.11 ± 0.018	0.10 ± 0.003	0.089 ± 0.0022
5th	1.08 ± 0.031	0.10 ± 0.006	0.091 ± 0.0041
10th	1.09 ± 0.027	0.12 ± 0.007	0.106 ± 0.0041
15th	1.12 ± 0.017	0.12 ± 0.004	0.108 ± 0.0023
20th	1.10 ± 0.017	0.13 ± 0.003	0.105 ± 0.0024
25th	1.07 ± 0.019	0.11 ± 0.004	0.103 ± 0.0020
30th	1.04 ± 0.017	0.11 ± 0.002	0.101 ± 0.0012
35th	1.09 ± 0.017	0.11 ± 0.004	0.098 ± 0.0018
40th	1.11 ± 0.025	0.11 ± 0.003	0.099 ± 0.0012
45th	1.14 ± 0.029	0.11 ± 0.004	0.104 ± 0.0042
50th	1.14 ± 0.020	0.11 ± 0.003	0.096 ± 0.0013
55th	1.24 ± 0.033	0.10 ± 0.003	0.086 ± 0.0014
60th	1.21 ± 0.034	0.11 ± 0.003	0.091 ± 0.0017

TABLE 3

Weight, volume, and specific gravity of new-laid eggs

ORDER THE EGGS WERE LAID	WEIGHT	VOLUME	SPECIFIC GRAVITY
	grams	*cc.*	
1st	33.98 ± 0.279	31.37 ± 0.419	1.010 ± 0.0021
5th	35.79 ± 0.373	33.55 ± 0.437	1.046 ± 0.0151
10th	38.58 ± 0.519	36.11 ± 0.518	1.074 ± 0.0029
15th	38.96 ± 0.428	36.58 ± 0.268	1.064 ± 0.0019
20th	40.80 ± 0.767	38.54 ± 0.706	1.066 ± 0.0014
25th	39.52 ± 0.365	37.20 ± 0.364	1.063 ± 0.0014
30th	40.31 ± 0.388	37.95 ± 0.696	1.056 ± 0.0012
35th	41.35 ± 0.339	38.87 ± 0.386	1.065 ± 0.0012
40th	41.30 ± 0.589	38.72 ± 0.186	1.065 ± 0.0014
45th	43.49 ± 0.404	40.83 ± 0.245	1.062 ± 0.0009
50th	44.38 ± 0.413	42.10 ± 0.282	1.060 ± 0.0011
55th	45.21 ± 0.522	42.38 ± 0.262	1.059 ± 0.0008
60th	46.04 ± 0.521	43.51 ± 0.313	1.058 ± 0.0012

TABLE 4

Dimensions of the yolk, and the yolk index of new-laid eggs

ORDER THE EGGS WERE LAID	DIAMETER OF YOLK	HEIGHT OF YOLK	YOLK INDEX
	cm.	*cm.*	
1st	3.48 ± 0.019	1.52 ± 0.012	0.436 ± 0.004
5th	3.57 ± 0.023	1.54 ± 0.018	0.437 ± 0.007
10th	3.73 ± 0.033	1.51 ± 0.016	0.430 ± 0.006
15th	3.77 ± 0.017	1.61 ± 0.013	0.432 ± 0.004
20th	3.80 ± 0.028	1.64 ± 0.012	0.433 ± 0.005
25th	3.76 ± 0.018	1.66 ± 0.019	0.424 ± 0.003
30th	3.71 ± 0.030	1.63 ± 0.016	0.434 ± 0.003
35th	3.82 ± 0.019	1.65 ± 0.011	0.422 ± 0.004
40th	3.63 ± 0.036	1.65 ± 0.013	0.435 ± 0.004
45th	3.82 ± 0.026	1.69 ± 0.016	0.442 ± 0.003
50th	3.85 ± 0.023	1.70 ± 0.016	0.416 ± 0.004
55th	3.88 ± 0.035	1.68 ± 0.015	0.431 ± 0.003
60th	4.02 ± 0.051	1.71 ± 0.011	0.432 ± 0.002

TABLE 5

Weight and strength of the yolk of new-laid eggs

ORDER THE EGGS WERE LAID	WEIGHT OF EGG	WEIGHT OF YOLK	PROPORTION OF YOLK TO EGG WEIGHT	STRENGTH OF YOLK
	grams	*grams*	*per cent*	
1st	33.98 ± 0.279	10.32 ± 0.129	30.38	35.10 ± 3.174
5th	35.79 ± 0.373	11.12 ± 0.136	31.08	28.00 ± 2.263
10th	38.58 ± 0.519	12.30 ± 0.214	31.88	31.00 ± 5.104
15th	38.96 ± 0.428	12.70 ± 0.138	32.60	22.52 ± 2.129
20th	40.80 ± 0.767	13.12 ± 0.261	32.17	27.00 ± 2.711
25th	39.52 ± 0.365	12.54 ± 0.178	31.74	33.99 ± 1.913
30th	40.31 ± 0.388	12.48 ± 0.262	30.97	25.47 ± 2.197
35th	41.35 ± 0.339	13.45 ± 0.204	32.53	42.14 ± 1.115
40th	41.30 ± 0.589	12.92 ± 0.283	31.27	26.00 ± 1.055
45th	43.49 ± 0.404	13.82 ± 0.278	31.79	35.00 ± 4.093
50th	44.38 ± 0.430	14.67 ± 0.184	33.06	25.61 ± 2.761
55th	45.21 ± 0.522	14.02 ± 0.226	31.02	33.35 ± 4.064
60th	46.04 ± 0.521	14.94 ± 0.283	32.44	21.77 ± 1.620

TABLE 6

Weight, volume of thick and thin albumen, and the proportion of the whole albumen to the total weight of new-laid eggs

ORDER THE EGGS WERE LAID	WEIGHT OF EGG	THICK ALBUMEN		THIN ALBUMEN		WHOLE ALBUMEN	PROPORTION OF WHOLE ALBUMEN TO EGG WEIGHT
	grams	*grams*	*cc.*	*grams*	*cc.*	*grams*	*per cent*
1st	33.98 ± 0.279	12.05 ± 0.214	10.39 ± 0.234	7.66 ± 0.164	7.49 ± 0.188	19.38 ± 0.191	57.02
5th	35.79 ± 0.373	12.58 ± 0.361	10.50 ± 0.372	8.54 ± 0.310	8.24 ± 0.324	20.89 ± 0.204	58.38
10th	38.58 ± 0.519	13.18 ± 0.322	10.50 ± 0.346	10.54 ± 0.343	10.26 ± 0.342	23.47 ± 0.480	60.83
15th	38.96 ± 0.428	11.52 ± 0.294	10.19 ± 0.224	10.17 ± 0.218	10.06 ± 0.227	22.09 ± 0.396	56.70
20th	40.80 ± 0.767	13.36 ± 0.366	10.97 ± 0.331	10.23 ± 0.255	9.91 ± 0.221	23.44 ± 0.368	57.44
25th	39.52 ± 0.365	12.81 ± 0.180	11.33 ± 0.273	9.78 ± 0.245	9.66 ± 0.245	22.72 ± 0.235	57.48
30th	40.31 ± 0.388	12.83 ± 0.306	11.17 ± 0.330	10.82 ± 0.341	10.49 ± 0.328	23.77 ± 0.338	58.97
35th	41.35 ± 0.339	12.10 ± 0.190	11.38 ± 0.233	10.92 ± 0.310	10.66 ± 0.310	23.81 ± 0.252	57.59
40th	41.30 ± 0.589	13.12 ± 0.328	11.37 ± 0.318	11.00 ± 0.271	10.68 ± 0.261	23.97 ± 0.182	58.03
45th	43.49 ± 0.404	14.02 ± 0.423	11.70 ± 0.344	11.28 ± 0.437	10.01 ± 0.416	25.24 ± 0.276	58.05
50th	44.38 ± 0.413	13.94 ± 0.363	12.90 ± 0.377	11.08 ± 0.280	10.88 ± 0.131	25.72 ± 0.307	57.95
55th	45.21 ± 0.522	15.49 ± 0.284	14.04 ± 0.259	10.55 ± 0.333	10.27 ± 0.291	25.97 ± 0.300	57.45
60th	46.04 ± 0.521	14.49 ± 0.336	13.00 ± 0.440	12.33 ± 0.339	11.30 ± 0.434	26.27 ± 0.348	57.06

TABLE 7

Angle of inclination and diameter of germs of new-laid eggs

ORDER THE EGGS WERE LAID	ANGLE OF INCLINATION	DIAMETER OF GERMS
	degrees	*cm.*
1st	9.09 ± 0.176	0.42 ± 0.012
5th	8.72 ± 0.309	0.38 ± 0.041
10th	8.45 ± 0.250	0.50 ± 0.024
15th	8.95 ± 0.108	0.49 ± 0.017
20th	9.07 ± 0.164	0.43 ± 0.016
25th	8.14 ± 0.161	0.45 ± 0.015
30th	8.68 ± 0.174	0.49 ± 0.020
35th	8.86 ± 0.180	0.46 ± 0.011
40th	8.93 ± 0.174	0.46 ± 0.010
45th	9.18 ± 0.191	0.45 ± 0.021
50th	9.12 ± 0.233	0.42 ± 0.010
55th	9.57 ± 0.233	0.46 ± 0.019
60th	9.40 ± 0.256	0.45 ± 0.016

TABLE 8

Weight of shell, its percentage to the total weight of the egg, and its thickness at butt, middle, and tip

ORDER THE EGGS WERE LAID	WEIGHT OF EGG	WEIGHT OF SHELL	PROPORTION OF SHELL TO EGG WEIGHT	THICKNESS OF SHELL		
				Butt	Middle	Tip
		grams	*per cent*	*mm.*	*mm.*	*mm.*
1st	33.98	3.74 ± 0.037	10.99	0.24 ± 0.003	0.25 ± 0.002	0.24 ± 0.003
5th	35.79	3.86 ± 0.052	10.80	0.25 ± 0.005	0.26 ± 0.003	0.25 ± 0.004
10th	38.58	4.13 ± 0.111	10.76	0.25 ± 0.007	0.26 ± 0.005	0.24 ± 0.007
15th	38.96	4.13 ± 0.060	10.61	0.25 ± 0.004	0.25 ± 0.004	0.25 ± 0.008
20th	40.80	4.11 ± 0.087	10.06	0.23 ± 0.005	0.25 ± 0.003	0.23 ± 0.004
25th	39.52	4.16 ± 0.062	10.54	0.25 ± 0.005	0.25 ± 0.004	0.25 ± 0.005
30th	40.31	4.20 ± 0.075	10.42	0.25 ± 0.005	0.26 ± 0.004	0.25 ± 0.006
35th	41.35	4.32 ± 0.068	10.44	0.23 ± 0.004	0.25 ± 0.004	0.25 ± 0.005
40th	41.30	4.42 ± 0.059	10.69	0.25 ± 0.005	0.26 ± 0.005	0.27 ± 0.005
45th	43.49	4.44 ± 0.095	10.21	0.23 ± 0.006	0.25 ± 0.006	0.25 ± 0.004
50th	44.38	4.47 ± 0.088	10.07	0.23 ± 0.005	0.25 ± 0.005	0.24 ± 0.004
55th	45.21	4.69 ± 0.082	10.37	0.24 ± 0.005	0.27 ± 0.004	0.25 ± 0.005
60th	46.04	4.71 ± 0.081	10.23	0.24 ± 0.007	0.27 ± 0.007	0.25 ± 0.004

TABLE 9

Color of yolk of new-laid eggs

ORDER THE EGGS WERE LAID	DEEP YELLOW	YELLOW	PALE YELLOW
	per cent	*per cent*	*per cent*
1st	45.10	54.90	—
5th	66.67	23.33	—
10th	30.77	30.77	38.46
15th	11.77	35.29	52.94
20th	21.05	42.11	36.84
25th	19.05	66.66	14.29
30th	31.57	36.84	31.59
35th	47.62	28.57	23.81
40th	46.67	40.00	13.33
45th	36.36	54.55	9.09
50th	52.94	35.30	11.76
55th	50.00	50.00	—
60th	40.00	60.00	—

TABLE 10

Color of albumen of new-laid eggs

ORDER THE EGGS WERE LAID	DARK SULFUR YELLOW	SULFUR YELLOW	LIGHT SULFUR YELLOW
	per cent	*per cent*	*per cent*
1st	15.69	47.06	37.25
5th	11.11	72.22	16.67
10th	38.46	38.46	23.08
15th	17.65	58.82	23.53
20th	21.05	42.11	36.84
25th	33.34	33.33	33.33
30th	52.63	21.05	26.32
35th	38.10	28.57	33.33
40th	40.00	40.00	20.00
45th	9.09	54.55	36.36
50th	23.53	41.18	35.29
55th	—	71.43	28.57
60th	20.00	60.00	20.00

TABLE 11

Relative proportion of each of the constituents of the egg in different clutches

CLUTCH NO.	WEIGHT OF EGG	SHELL	YOLK	ALBUMEN
	grams	*per cent*	*per cent*	*per cent*
1	36.00	11.07	31.32	57.61
2	38.13	10.82	31.36	57.81
3	39.79	10.33	31.05	58.62
4	39.02	10.40	30.81	58.78
5	41.13	10.19	31.00	58.80
6	40.83	10.47	31.45	58.07
7	40.04	10.39	32.29	57.32
8	43.13	10.34	32.23	57.43
9	41.56	10.25	31.81	57.93
10	42.75	10.09	32.51	57.40
11	43.75	10.36	33.19	56.45
12	44.90	10.47	33.09	56.43
13	44.06	10.69	33.73	55.58
14	45.04	10.71	32.35	56.95

TABLE 12

Relative proportion of each of the constituents of the egg in different positions in ten different clutches

ORDER THE EGGS WERE LAID	WEIGHT OF EGG	SHELL	YOLK	ALBUMEN
	grams	*per cent*	*per cent*	*per cent*
1	40.72	10.54	31.32	58.13
2	40.81	10.58	31.95	57.47
3	40.06	10.54	32.44	57.08
4	40.16	10.07	31.12	59.14
5	41.09	10.06	31.07	58.34
6	41.84	10.85	30.57	59.02
7	32.62	9.39	34.17	56.44
8	42.70	9.88	32.36	57.82
9	40.42	9.57	29.79	60.64
10	42.55	9.79	29.66	60.56

A COMPARATIVE STUDY OF THE AMOUNT OF SOILAGE AND SILAGE CONSUMED BY PHILIPPINE AND NELLORE CATTLE[1]

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Various feeding experiments showed the amounts of roughage consumed by cattle as follows:

Sanborn (1893) fed yearling steers with moist hay or straw silage in addition to grains and claimed that the maximum amount of silage that the animals could be induced to eat was 30 lb. (13.6 kgm.).

Griffiths (1904) reported that a full grown steer, on prickly pear alone, will consume from 125 to 200 lb. (56.7 to 90.7 kgm.) daily.

Wilson (1912) worked on the value of silage as a sole ration for steers in winter-fed animals weighing approximately 770 lb. (349.3 kgm.) per head at the beginning of the test. One lot, fed corn silage alone, consumed an average of 63 lb. (28.6 kgm.) per head daily at the close of the experiment. Another lot, fed corn fodder silage, consumed per head per day an average of 45 lb. (20.4 kgm.).

Wilson (1915) fed yearling grade Aberdeen-Angus and found that lot 2, fed all the corn silage they would take, consumed 62.5 lb. (28.3 kgm.) per head daily.

Wilson and Kuhlman (1920), reporting on the value of corn silage from several varieties of corn for fattening steers weighing approximately 980 lb. (444.5 kgm.), found that those receiving sweet corn silage consumed an average of 55.40 lb. (25.1 kgm.) per head daily; those fed White Dent corn silage, an average of 53.06 lb. (24.1 kgm.); those receiving Rainbow Flint corn silage, an average of 63.89 lb. (29.0 kgm.); and those given Reed's Yellow Dent corn silage, an average of 62.91 lb. (28.5 kgm.).

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[1] Experiment Station contribution No. 1326.

The object of the work reported in this paper was to determine the comparative amount of soilage and silage consumed by Philippine and Nellore cattle, and its relation to the live weight of the animals.

This investigation was conducted in the Department of Animal Husbandry, from October, 1931, to June, 1936.

Animals

Seven Philippine and six Nellore cattle were used in this experiment. The Philippine animals consisted of one bull, one steer, and five cows. Bull No. 158 had to be replaced with steer No. 70 when the former contracted surra. There was an old cow in this group. Of the younger stock the range in age was from 7 to 16 years, the average being 10.6 years. Their heights ranged from 107.0 cm. to 129.0 cm., the average being 116.2 cm. The average weight of the animals during the experiment ranged from 250.3 kgm. to 463.3 kgm., the general average being 340.0 kgm. The Nellore cattle consisted of one bull and five cows. As with the Philippine cattle, there was also an old cow among them. The age of the younger animals varied from 6 to 12 years, the average being 8.8 years. The height ranged from 121.0 cm. to 137.0 cm., the average being 125.4 cm. The average weight during the experiment was from 314.8 kgm. to 568.8 kgm., the general average being 368.2 kgm. (table 1).

Forages

The soilage used was napier grass (*Pennisetum purpureum* Schum.).

The silage was made from corn of the Yellow Flint variety from Laguna.

Barn

A barn with concrete floor and manger was used. Partitions in the manger were put up to separate the feed of one animal from that of another. The stanchion in each stall served to keep the animal in place.

Preliminary trial

For a period of about three months, the animals were subjected to a preliminary feeding trial. They were brought from the pasture and fed in the barn once a week. In this way, an estimate of the amount of feed necessary to carry out the investigation was determined. The animals were also accustomed to being handled at this time.

Feeding

At 5:30 p.m., previous to the day of feeding, the animals were brought from the pasture and placed in their respective stalls in the barn. Here they remained the whole night without feeding. The following day, the animals were given all the feed that they would consume. The first feeding was made at 5:30-8:00 a.m., the second, at 11:00 a.m.-1:00 p.m., and the third, at 3:00-5:30 p.m. Effort was made to distribute the feeding uniformly throughout the year, but because of scarcity of feed during the drier months, feeding during this time was relatively less than at the time when the feed was abundant.

The animals of both breeds, except the Philippine bull, were each fed soilage twenty-four days during the investigation. Philippine bull No. 158 was fed twenty-one days.. In the case of silage, each animal was fed sixteen days.

Recording

Records were taken of the feed consumed by each of the animals. In determining the consumption of soilage and silage, the weights of the materials supplied during the day were recorded and totaled. The left-over was then collected and weighed each day in the afternoon. The difference between the total weight of the feed given and that of the left-over represented the amount consumed during the day.

DISCUSSION OF RESULTS

Soilage consumption

Table 2 shows that the minimum consumption of soilage by a Philippine cow, No. 198, amounted to 18.89 ± 0.11 kgm. daily. The maximum daily consumption was 29.65 ± 0.21 kgm. by cow No. 174. The mean consumption of all Philippine cows was 28.39 ± 0.13 kgm. a head daily. The consumption of the Philippine bull varied from 24.9 to 59.9 kgm. a day, the mean being 44.02 ± 0.33 kgm. Among the Nellore cows, the lowest consumption, by cow No. 6, amounted to 17.11 ± 0.14 kgm., and the highest consumption, by cow No. 361, 30.40 ± 0.16 kgm. daily. The mean consumption of all the Nellore cows was 28.02 ± 0.13 kgm. a head daily. The range in the daily consumption of the Nellore bull was from 29.5 to 55.3 kgm., the mean being 40.38 ± 0.22 kgm. a day.

Silage consumption

The amount of silage consumed by Philippine cows, as shown in table 3, ranged from 16.75 ± 0.20 kgm. by cow No. 198 to 21.93 ± 0.41 by cow No. 174, the mean for all cows being 19.21 ± 0.15 kgm. a head daily. The Philippine steer consumed from 14.5 to 25.9 kgm. and a mean of 21.25 ± 0.38 kgm. daily. The Nellore cows consumed from 17.84 ± 0.14 kgm. with No. 6 to 24.74 ± 0.26 kgm. with No. 41, the mean consumption of all cows being 23.95 ± 0.18 kgm. a head daily. The Nellore bull consumed from 28.6 to 44.0 kgm. and a mean of 34.23 ± 0.34 kgm. daily.

Relation between the amount of soilage consumed and the live weight of animals

The relation between the live weight of animals and the amount of soilage consumed is shown in table 4. The amount of soilage consumed per 100 kgm. live weight of Philippine cows ranged from 8.6 kgm. with cow No. 198 to 11.9 kgm. with cow No. 215, the average being 11.7 kgm. Philippine bull No. 158 consumed 9.5 kgm. of soilage per 100 kgm. live weight. Among the Nellore cows, the range in the amount of soilage consumed per 100 kgm. of live weight was from 5.4 kgm. with cow No. 6 to 9.1 kgm. with cow No. 41, the average being 8.5 kgm. Nellore bull No. 21 consumed 7.1 kgm. of soilage per 100 kgm. live weight.

It is evident that in either the Philippine or Nellore breed, the amount of soilage consumed by the cows was greater than by the bulls per 100 kgm. live weight. It is also true that in all cases except one, the Philippine cows consumed greater amounts of soilage than did the Nellore cows per 100 kgm. live weight.

Relation between the amount of silage consumed and the live weight of animals

Table 5 shows the relation between the amount of silage consumed and the live weight of animals. The range in the amount of silage taken by Philippine cows per 100 kgm. live weight was from 7.0 kgm. with cow No. 54 to 8.6 kgm. with cow No. 174. The average for all the cows was 7.9 kgm. In the case of Philippine steer No. 70, the consumption was 5.0 kgm. per 100 kgm. live weight. Among the Nellore cows, the consumption varied from 5.7 kgm. with cow No. 6 to 7.7 kgm. with cow No. 41, the average being 7.3 kgm. per 100 kgm. live weight. The Nellore bull consumed 6.0 kgm. per 100 kgm. live weight.

It is interesting to note that while Philippine cattle were comparatively better feeders of soilage than the Nellores, the amount of silage they consumed was about equal to that taken by the Nellores per 100 kgm. live weight.

The bulls of either breed consumed lower amounts of silage per 100 kgm. live weight than did the cows; the same results obtained in soilage feeding.

SUMMARY AND CONCLUSIONS

1. Determinations of the comparative amounts of soilage and silage consumed by Philippine and Nellore cattle were made.

2. Napier grass was used as soilage and the Laguna Yellow Flint variety of corn as silage.

3. The consumption of soilage by Philippine and Nellore cows was statistically the same. Between the bulls of the two breeds, the Philippine animal consumed more than did the Nellore. The mean consumption among Philippine cows was 28.39 ± 0.13 kgm., and among Nellore cows 28.02 ± 0.13 kgm. per head daily. The Philippine bull took 44.02 ± 0.33 kgm. and the Nellore bull 40.38 ± 0.22 kgm.

4. With silage used as feed, the consumption was significantly greater among Nellore cattle than among Philippine cattle of both sexes. The mean consumption of Philippine cows was 19.21 ± 0.15 kgm. per head daily; that of the Philippine steer, 21.25 ± 0.38 kgm. The Nellore cows had a mean consumption of 23.95 ± 0.18 kgm. per head daily, and the Nellore bull, 34.23 ± 0.38 kgm.

5. The Philippine cattle consumed proportionately more soilage than Nellore cattle of either sex per 100 kgm. of their live weight. The females of the two breeds consumed more soilage than did the males per 100 kgm. live weight. The average amount of soilage consumed by Philippine cows per 100 kgm. live weight was 11.7 kgm.; that of the Philippine bull, 9.5 kgm. In the case of Nellore cows, the amount was on an average of 8.5 kgm., and of the Nellore bull, 7.1 kgm.

6. When silage is fed, the amount consumed by Philippine and Nellore cattle of both sexes per 100 kgm. live weight was about equal. The males of either breed took less feed than did the cows per 100 kgm. live weight. The average consumption among the Philippine cows per 100 kgm. live weight was 7.9 kgm.; that of the

Philippine steer, 5.0 kgm. The corresponding figure for Nellore cows was on an average of 7.9 kgm. and for the Nellore bull, 6.0 kgm.

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TABLE 1

Sex, age, height, and weight of cattle

ANIMAL NUMBER	SEX	DATE OF BIRTH	HEIGHT	AVERAGE WEIGHT
			cm.	*kgm.*
Philippine cattle				
54	Female	Unknown (very old)	108.2	250.3
90	"	Unknown (medium age)	109.3	260.9
174	"	June 12, 1925	107.0	254.4
198	"	Nov. 12, 1930	106.3	219.1
215	"	Oct. 21, 1931	107.3	227.7
		Average	107.6	242.5
70 (steer)	Male	Unknown (medium age)	126.0	426.4
158 (bull)	"	Unknown (medium age)	129.0	463.3
		Average	127.2	444.8
Nellore cattle				
6	Female	Unknown (very old)	123.4	314.9
30	"	August 8, 1922	122.4	324.8
34	"	January 6, 1924	121.0	314.8
41	"	April 10, 1927	123.5	321.5
365	"	Unknown (medium age)	125.0	364.4
		Average	123.1	328.1
21 (bull)	Male	October 18, 1919	137.0	568.8

TABLE 2

Soilage consumption by cattle

PHILIPPINE CATTLE	RANGE IN DAILY CONSUMPTION	MEAN DAILY CONSUMPTION	NELLORE CATTLE	RANGE IN DAILY CONSUMPTION	MEAN DAILY CONSUMPTION
number	*kgm.*	*kgm.*	*number*	*kgm.*	*kgm.*
Cows			*Cows*		
54	15.9 to 34.0	25.89 ± 0.14	6	10.0 to 21.8	17.11 ± 0.14
90	12.7 to 37.2	26.24 ± 0.23	30	18.1 to 35.8	25.86 ± 0.18
174	16.3 to 43.1	29.65 ± 0.21	34	20.4 to 36.3	26.93 ± 0.16
198	10.4 to 24.0	18.89 ± 0.11	41	20.0 to 42.2	29.37 ± 0.25
215	21.8 to 34.0	27.09 ± 0.13	365	23.1 to 42.2	30.40 ± 0.16
For all cows		28.39 ± 0.13	For all cows		28.02 ± 0.13
Bull			*Bull*		
158	24.9 to 59.9	44.02 ± 0.33	21	29.5 to 55.3	40.38 ± 0.22

TABLE 3

Silage consumption by cattle

PHILIPPINE CATTLE	RANGE IN DAILY CONSUMPTION	MEAN DAILY CONSUMPTION	NELLORE CATTLE	RANGE IN DAILY CONSUMPTION	MEAN DAILY CONSUMPTION
number	*kgm.*	*kgm.*	*number*	*kgm.*	*kgm.*
Cows			*Cows*		
54	12.7 to 22.7	17.43 ± 0.30	6	14.5 to 20.9	17.84 ± 0.14
90	15.0 to 29.0	20.58 ± 0.39	30	13.6 to 30.8	20.55 ± 0.27
174	16.3 to 33.6	21.93 ± 0.41	34	14.5 to 28.6	22.25 ± 0.25
198	15.4 to 18.6	16.75 ± 0.20	41	13.6 to 29.0	24.74 ± 0.26
215	15.0 to 19.5	17.31 ± 0.11	365	15.4 to 29.0	24.18 ± 0.30
For all cows		19.21 ± 0.15	For all cows		23.95 ± 0.18
Steer			*Bull*		
70	14.5 to 25.9	21.25 ± 0.38	21	28.6 to 44.0	34.23 ± 0.34

TABLE 4

Relation between the amount of soilage consumed and the live weight of animals

ANIMAL NUMBER	LIVE WEIGHT OF ANIMALS	MEAN DAILY CONSUMPTION OF SOILAGE	AMOUNT OF SOILAGE CONSUMED PER 100 KGM. LIVE WEIGHT
Philippine cattle	*kgm.*	*kgm.*	*kgm.*
Cows			
54	250.3	25.89 ± 0.14	10.3
90	260.9	26.24 ± 0.23	10.0
174	254.4	29.65 ± 0.21	11.7
198	219.1	18.89 ± 0.11	8.6
215	227.7	27.09 ± 0.13	11.9
Average	242.5	28.39 ± 0.13	11.7
Bull			
158	463.3	44.02 ± 0.33	9.5
Nellore cattle			
Cows			
6	314.9	17.11 ± 0.14	5.4
30	324.8	25.86 ± 0.18	8.0
34	314.8	26.93 ± 0.16	8.5
41	321.5	29.37 ± 0.25	9.1
365	364.4	30.40 ± 0.16	8.3
Average	328.1	28.02 ± 0.13	8.5
Bull			
21	568.8	40.38 ± 0.22	7.1

TABLE 5

Relation between the amount of silage consumed and the live weight of animals

ANIMAL NUMBER	LIVE WEIGHT OF ANIMALS	MEAN DAILY CONSUMPTION OF SILAGE	AMOUNT OF SILAGE CONSUMED PER 100 KGM. LIVE WEIGHT
Philippine cattle	*kgm.*	*kgm.*	*kgm.*
Cows			
54	250.3	17.43 ± 0.30	7.0
90	260.9	20.58 ± 0.39	7.9
174	254.4	21.93 ± 0.41	8.6
198	219.1	16.75 ± 0.20	7.7
215	227.7	17.31 ± 0.11	7.6
Average	242.5	19.21 ± 0.15	7.9
Steer			
70	426.4	21.25 ± 0.38	5.0
Nellore cattle			
Cows			
6	314.9	17.84 ± 0.14	5.7
30	324.8	20.55 ± 0.27	6.3
34	314.8	22.25 ± 0.25	7.1
41	321.5	24.74 ± 0.26	7.7
365	364.4	24.18 ± 0.30	6.6
Average	328.1	23.95 ± 0.18	7.3
Bull			
21	568.8	34.23 ± 0.34	6.0

A STUDY OF THE GROWTH HABIT OF RICE PLANTS: III. RATOONS AND GRAIN SIZE[1]

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Ratooning rice plants is very seldom practised in the Philippines. In Calamba, Laguna, farmers sometimes ratoon their rice plants in places where it is hardly possible for farm animals to work efficiently. John (1927) states that at least in Chinleput district, India, rice plants of a special variety, *uthiri kar*, are ratooned, provided irrigation water is available and harvesting is done when the stubble is still green.

This paper presents some data on the measurements of grains harvested from the first crop and their ratoons, grown both in tin cans and in the field. As far as the writer is aware, there has been no such study ever carried on in the Philippines, although a consensus of opinion prevails among farmers and those working with rice that ratoons do produce smaller grains than the first harvest. It is also a common experience that ratoons produce less grains, smaller panicles, more unfilled grains per panicle, and shorter culms.

MATERIALS AND METHODS

The seeds used in this study were those harvested by Juliano (1938). These were a pure line Guinangang rice variety obtained from Calamba, Laguna, on October 15, 1936. Two sets of plants were studied. One of the sets included plants grown in tin cans, four plants to the can, following the procedure employed by Juliano (1938), and the other set was composed of plants grown in small paddies near the Department of Agricultural Botany.

Can cultures. Thirty tin cans planted to rice from among those employed by Mr. Ciriaco M. Ramos, a research student under the direct supervision of the writer, were selected on April 20, 1938, after Mr. Ramos had harvested all the panicles which represent the first harvest in this paper. On April 22, 1938, the stubbles were cut so as to leave approximately ten centimeters of the green stems above the ground. To each of fifteen of these tin can cultures 4.71 grams of ammonium sulfate fertilizer were added on May 8, 1938. The other fifteen can cultures were not fertilized at all and served as control. All the tin can cultures were arranged in rows inside a wire cage to protect the plants from birds and other stray animals. The heads were collected by hand as fast as they matured, and the grains obtained from each can were separately stored in paper envelopes and carefully labeled.

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Field cultures. The field plants were grown in two small paddies near the Department of Agricultural Botany, and artificially irrigated with tap water from a faucet. After the main crop was harvested, the stubble was also cut to approximately ten centimeters from the ground on April 26, 1938. One field was fertilized on May 8, 1938 with 211.93 grams of ammonium sulfate, thus giving 1.1775 grams per plant or hill. The other field was not fertilized at all but served as control. These two paddies were contiguous to each other, the unfertilized one being higher than the fertilized in order to minimize as much as possible seepage of fertilizer to the control paddy. Besides, the dike separating them was reinforced to about a foot deep with sheets of galvanized iron.

The panicles from the individual hills in each paddy were collected as fast as they matured, and the harvests from each hill were carefully kept and labeled.

Measurements of grains. From the ratoon plants grown in tin cans, a total of 5,033 hulled grains were measured for their length, breadth, and thickness with the use of a microcaliper, and from the main harvests the same number of hulled grains were also measured from the same can cultures for comparison. From the field plants, 4,960 hulled grains were taken, and for comparison the same number of hulled grains from the main harvests were measured. Therefore, a total of 19,986 hulled grains were employed in this study.

RESULTS AND DISCUSSION

General observations

Ratooning is due mainly to proper development of axillary buds at the nodes of the stubbles left after the normal harvest is gathered. It seems that the stooling habit is a distinct varietal character, although this may be greatly controlled by the time the first panicles are harvested and other environmental conditions, and the development of the axillary buds. When a variety with inherent capacity to ratoon is cut just at the time of ripening, so that the straw is still green and the soil moist, especially when supplemented by a further supply of moisture in the soil either by rain or irrigation water, then the stubble of that variety will produce shoots and ultimately grain. If, however, the same variety is harvested when it is fully ripe and no supply of water or other suitable conditions are available, the stubble will not produce any effective growth.

The ratooned plants grown in cans actually had their first panicles mature on May 13, 1938, just 21 days after the stubble was cut. Subsequent panicles from the rest of the cultures matured up to August 15, 1938. The panicles of the field plants also exhibited practically the same character, although the first panicle to mature was harvested on July 10, 1938, and all the grains were gathered from July 26, to 28, 1938. Ratoon plants grown in tin cans, whether fertilized or not, produced panicles much earlier than those in the field, and the time interval between maturation of their first and last panicles was 58 days.

Although no actual measurements were made by the writer, it was observed that plants of the first crop grown in cans were much shorter than those planted in the field and their ratoons were in both cases shorter than the first crop plants. The culms were narrower and the panicles smaller in the ratoons than in the first crop. Grain setting was also poor in the ratoon plants. This had been observed also by John (1927) in India.

The life period of a ratoon crop is markedly less than that of the normal crop (John, 1927). According to him, the number of days ranged from a month to a month and a half from the shooting of these out-of-season tillers to the maturation of the grains in the different ratoons. As to height (six plants as basis of comparison) the ratoon plants were considerably shorter, possessing comparatively thinner culms, although no regular measurements were made. The panicles of the ratoon crops was also considerably shorter than those of the first crop with less percentage of unset grains.

Mean length

For plants grown in cans, the mean length of hulled grains from the first crop fertilized with ammonium sulfate was significantly greater than when not fertilized (table 1). In the fertilized ratoon crop the mean length of the hulled grains was also greater than that of the control grains, although the difference was insignificant. The first crop from plants grown in the field also exhibited larger mean length when fertilized and the difference was significant, while in the ratoons the mean length of the control was insignificantly larger than that of the experimental plants. Generally speaking, therefore, the mean length of hulled grains of the fertilized plants was actually increased, whether they were from the first crop or from the ratoons, except in one instance where the difference was insignificant in favor of the control plants from the ratoons.

If the mean length of hulled grains of the first crop is compared with that of the ratoons (table 2) in three cases out of four the former are larger than the latter, and of these three cases, two are significant. The exceptionally contradicting result was obtained from the first crop of the control plants grown in tin cans, although the difference was insignificant in favor of the ratoon grains. From these results, it can be concluded that the mean length of hulled grains from the first crop is greater than that from the ratoons. John (1927), who measured only fifteen unhulled grains each from the normal crop and the ratoons, also found that ratoon seeds were much shorter than the first crop seeds. The consensus of opinion that first crop seeds are longer than the ratoon grains is herein confirmed.

Mean breadth

The effect of fertilization on the mean breadth of hulled grains from the first crop and from the ratoon was only evident (table 1) in plants grown in tin cans. In these plants the fertilizer had increased the mean breadth of the hulled grains from both the first crop and the ratoons, and the differences were insignificant. In field grown plants, however, the hulled grains from the main crop and from the ratoons when fertilized, produced less mean breadth, and the difference was significant in first crop and insignificant in the ratoons. These divergent results may be attributed to such factors as seepage and the like, which were practically beyond the control of the writer and which were actually controlled in the plants grown in the cans.

The mean breadth of hulled grains from the first crop was insignificantly larger than that of the ratoon crop in two cases out of three (table 2). The mean breadth of the hulled grains from the fertilized ratoon field plants was insignificantly larger than that of the first crop. In other words, the mean breadth of hulled grains from the first crop was greater than that of the ratoon crop, a condition found to be true by John (1927), who also found that unhulled grains from the first crop exhibited greater breadth than those from their ratoons.

Mean thickness

In mean thickness of hulled grains from both harvests of fertilized lots, the first crop showed more than that of the ratoons in three cases out of four, although all their differences were insignificant (table 1).

There were rather more variable results obtained when the mean thickness of hulled grains from the first crop was compared with that from the ratoons (table 2). In the plants grown in cans, the hulled grains from the first crop were relatively thicker whether they were fertilized or not. In the unfertilized plants, the difference was insignificant, whereas in the fertilized ones, this was significant. In the field grown series, all the hulled grains from the first crop were much thinner than those from the ratoon, and all the differences were significant. This discrepancy must be due again to factors such as seepage and the like, which were beyond the control of the writer. In tin cans, no such seepage was possible and, therefore, the plants were under controlled conditions. In general, however, the mean thickness of hulled grains is not greatly affected by ratooning. These figures, therefore, do not entirely support the findings of John (1927), who measured only fifteen unhulled grains each from the first crop and the ratoons and reported that ratoon grains were thinner than those from the normal crop.

Usually size of the grains either hulled or unhulled, is directly proportional to their weight and volume (Apaoan, 1939). John (1927) observed that the weight of unhulled grains from ratoons was less than the weight of those from the first crop when based on the weight of 50 seed-samples of each kind. Furthermore, this investigator found practically no difference between the normal crop and the ratoon in vitality, although the germination of the ratoon grains was prolonged for a number of days, while that of the first crop seeds took place within the first two days, and a good number germinated within the first day. Grains from ratoons perhaps lack the energy and are not wholly fit for seed purposes.

John (1927) recommended ratooning rice plants in India where natural facilities necessary to maintain a paddy from a month to a month and a half exist.

SUMMARY

The present study gives some data on Guinangang rice plants grown and ratooned in tin cans and in the field. The results obtained may be summarized as follows:

1. In growth habits ratoon plants differ markedly from the first crop plants in that the life duration of the former is much shorter than that of the latter. In this experiment the panicles were shorter, the culms were also shorter and thinner, and the percentage of setting of the grains was much less than that of the first crop.

2. Generally, marked increase in the mean length and mean breadth of hulled grains was brought out by fertilization especially with can grown plants whether they were from the first crop or ratoons. In field grown plants no such marked difference in favor of fertilization was noted especially with mean breadth. Fertilization affected favorably the mean thickness of hulled grains in three cases out of four.

3. The mean length and breadth of hulled grains from the first crop were generally greater than those of the ratoons, but the mean thickness seemed to be rather adversely affected especially when grown in the field where factors beyond the control of the experimenter existed.

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TABLE 1

Mean length, breadth, and thickness of hulled grains obtained from the first crop and ratoons grown in cans and in the field

CAN PLANTS

		LENGTH			BREADTH			THICKNESS		
Kind of plants	Treatments	Mean	Standard deviation	Difference	Mean	Standard deviation	Difference	Mean	Standard deviation	Difference
		mm	*mm*	*mm*	*mm*	*mm*	*mm*	*mm*	*mm*	*mm*
First Crop	Control	5.8549 ± 0.0369	1.7440	0.2354 ± 0.0480	2.3124 ± 0.0371	1.8010	0.0793 ± 0.0489 [a]	1.6720 ± 0.0297	1.4040	0.0753 ± 0.0387 [a]
	Fertilized	6.0903 ± 0.0313	1.6280		2.3917 ± 0.0316	1.7370		1.7473 ± 0.0248	1.3120	
Ratoon	Control	5.8772 ± 0.0483	2.2920	0.0450 ± 0.0592 [a]	2.2455 ± 0.0377	1.7400	0.0231 ± 0.0472 [a]	1.6715 ± 0.0264	1.2320	0.0035 ± 0.0330 [a]
	Fertilized	5.8322 ± 0.0338	1.7990		2.2686 ± 0.0283	1.5040		1.6680 ± 0.0202	1.0660	

FIELD PLANTS

		LENGTH			BREADTH			THICKNESS		
Kind of plants	Treatments	Mean	Standard deviation	Difference	Mean	Standard deviation	Difference	Mean	Standard deviation	Difference
First Crop	Control	5.7905 ± 0.0311	1.5586	0.0881 ± 0.0436	2.4593 ± 0.0266	1.3330	0.1289 ± 0.0391	1.6167 ± 0.0205	1.0285	0.0436 ± 0.0307 [a]
	Fertilized	5.8886 ± 0.0305	1.5140		2.3304 ± 0.0285	1.4170		1.6603 ± 0.0260	1.2918	
Ratoon	Control	5.9669 ± 0.0328	1.6407	0.0879 ± 0.0468 [a]	2.3941 ± 0.0270	1.3348	0.0094 ± 0.0391 [a]	1.7450 ± 0.0212	1.0625	0.0056 ± 0.0318 [a]
	Fertilized	5.8790 ± 0.0334	1.6600		2.3847 ± 0.0283	1.4080		1.7506 ± 0.0237	1.1790	

[a] Insignificant.

TABLE 2

Differences in mean sizes of hulled grains from the first crop and from the ratoons [a]

ITEMS	LENGTH	BREADTH	THICKNESS
	mm.	*mm.*	*mm.*
Can culture—control	—0.0223 ± 0.0609 [b]	0.0669 ± 0.0529 [b]	0.0005 ± 0.0396 [b]
Can culture—fertilized	0.2581 ± 0.0458	0.1231 ± 0.0426	0.0793 ± 0.0319
Field culture—control	0.1764 ± 0.0452	0.0652 ± 0.0378 [b]	—0.1283 ± 0.0295
Field culture—fertilized	0.0086 ± 0.0452 [b]	—0.0543 ± 0.0402 [b]	—0.0903 ± 0.0330

[a] Minus sign before the figure indicates that the difference is in favor of the ratoon grains.

[b] Insignificant.

RICE STRAW AND MOLASSES AS SUPPLEMENTS TO PASTURE FEEDS FOR RANGE CATTLE[1]

RAFAEL G. MACAHILIG

In the Philippines, supplementing pasture feeds for range cattle is not given much concern by cattle raisers in general. They do not attach sufficient importance to the fact that during the dry season the capacity of pastures is very much less than during the wet season, with the result that the animals suffer much from lack of sufficient feeds. Rice straw and molasses are two available, cheap feeds in the Philippines. It is, therefore, important to determine the value and cost of these when used as supplements to pasture feeds; hence, this work was undertaken.

Patterson and Outwater (1907) report that the addition of molasses to a ration tends to increase the digestibility of both hay and grain feed but that the digestibility of protein is sometimes adversely affected by it. The fact, however, that there is available energy in the molasses compensates for the loss in protein.

Williams (1925) states that the digestibility of crude fiber, nitrogen-free extract, and ether extract is not uniformly affected by molasses in the ration. According to him, molasses tends to depress the digestibility of crude protein and dry matter in general. This depression, however, is slight.

Henry and Morrison (1929) state that cane molasses is much relished by farm animals and does not have the purging effect of beet molasses when fed in large amounts. It improves the palatability of feeds.

Roces (1935) found that in feeding molasses, rice straw, and copra meal to cattle for a period of 143 days during the rainy season, when the vegetation of the pasture was luxuriant and plentiful, the average daily consumption per animal of molasses, rice straw, and copra meal was 2.84 kgm., 1.47 kgm., and 1.51 kgm., respectively. The animals fed with these supplements gained in weight on the average of 67.5 kgm. per head, whereas the animals of the nonsupplemented lot lost in weight on the average of 13.1 kgm. per animal. He further states that it would have been more economical to shorten the feeding period to 90 or 120 days.

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[1] Experiment Station contribution No. 1328. Prepared in the Department of Animal Husbandry under the direction of Associate Professor Valente Villegas.

Andouard (1901), cited by Roces (1935), claimed that on account of its low ash content, cane molasses is superior to beet molasses for animal feeding.

Labh Singh and Gambhir Singh (1934) report that 2 pounds (0.91 kgm.) of molasses replaced 2 pounds (0.91 kgm.) of maize and 0.9 pound (0.41 kgm.) of mixed roughage, but that an additional 2 pounds (0.91 kgm.) of molasses replaced only 2.5 pounds (1.14 kgm.) of mixed roughage. They explained that the lower efficiency of the second 2 pounds (0.91 kgm.) of molasses might be due to the depression of the digestibility of the basal ration as a result of feeding 4 pounds (1.82 kgm.) of molasses per animal per day. They further stated that the replacement of one pound (0.45 kgm.) of wheat bran in the mixed ration, which was rich in protein, by one pound (0.45 kgm.) of molasses per day for a cow, was successfully done without affecting the quality and quantity of the milk. In another experiment the same authors (1935) state that no harmful effect of feeding cane molasses during two consecutive winters to the same animals was noticed, and that feeding up to 2 pounds (0.91 kgm.) of cane molasses per day to an animal is quite safe and economical.

Calloway (1921) states that the average cost of raising a calf to six months of age with feeds consisting of wheat bran, corn meal, velvet bean meal, and oats was $60.00 without molasses and $54.00 with molasses. The roughage consisted of corn and soybean silage and of hay of several varieties.

Brintnall (1921) reports that practically one pound (0.45 kgm.) of molasses is equal to one pound (0.45 kgm.) of corn as a feed to dairy stock with silage and Johnson grass hay as roughage, and bran, cottonseed meal, and shorts as concentrates. He fed as high as 4 to 5 pounds (1.82 to 2.27 kgm.) of molasses to a cow per day. He further stated that 2 to 5 pounds (0.91 kgm. to 2.27 kgm.) of molasses was given as a supplementary feed to cows on pasture.

Krauss (1930) states that the superiority of cane molasses to beet molasses for the prevention of anemia in rats was due to its higher iron and copper content.

This work was undertaken with the following objects in view: (*a*) To determine the amount and cost of rice straw and molasses as supplements to pasture feed for range cattle. (*b*) To find out the effect on the condition of the animals as shown by their weights when fed with the supplements.

This study was conducted in the Department of Animal Husbandry, College of Agriculture. It was begun on January, 1936, and ended on January, 1937, covering a period of one year.

Animals

Twelve female cattle of the Philamin herd of the College of Agriculture were used in this study. During the dry season feeding, the ages varied from one year and three months to eleven years and ten months, whereas during the wet season, they were from one year and seven months to six years and four months.

The animals were divided into two lots of three cows and three heifers each. The average weight of the animals fed during the dry season was 251.73 kgm. in lot I, and 251.68 kgm. in lot II. The average age was four years, five months, and 24 days in lot I, and four years, five months, and nine days in lot II. With animals fed during the wet season, the average weight was 263.25 kgm. in lot I and 238.83 kgm. in lot II. The average age was three years and seven months in lot I and three years and five months in lot II.

Pasture

The animals in all the lots were kept in the same pasture of eight hectares. During the summer, the vegetation in the pasture was poor, whereas during the rainy season, the grass had improved, although it was not very luxuriant. Several species of weeds disturbed their development. Among them, magilik (*Premna cumingiana* Schauer) and sambong (*Blumea balsamifera* [Linn.] DC.) were predominant.

Supplements

Rice straw and molasses were used as supplements. The molasses was obtained from the Calamba Sugar Estate and The Philippine Sugar Estates Development Co., Calamba, Laguna. The cost was, on the average, ₱0.009 a kilogram. The rice straw used was baled in the College of Agriculture at a cost of ₱0.008 a kilogram.

Table 1 shows the chemical analysis of the supplements used. According to this table, the molasses from the two centrals had about the same chemical composition except in fat which was greater in the one obtained from the Calamba Sugar Estate. The calorific value of the two molasses was almost the same.

General plan

Aside from the pasture feeds, the animals in lot I were given rice straw and molasses as supplements for about one to two hours every afternoon. Lot II animals had nothing but the pasture feeds at all times. The experiment was divided into two parts: the first, from March 1 to June 21, 1936, was designated as the dry season period; and the second, from June 22, 1936, to January 3, 1937, was designated as the wet season. Each of these was in turn divided into 4-week periods.

Feeding

There was a preliminary feeding period of 20 days during which the animals in lot I were fed the supplements. The amount and proportion of rice straw and molasses consumed by them daily were determined. They were given all they would take of each supplement. Owing to the laxative effect that an abundance of molasses has on the animal, however, care was taken that not too much of it was consumed. The consistency of the feces was observed to determine whether the amount of molasses given was excessive or not. Also the manner of mixing the molasses with the rice straw was studied. It was observed that a 1:2.2 ratio of rice straw and molasses was relished by the animals, although during the wet season, the ratio was 1:1. Pure molasses was also consumed by them. The most practical way of giving the molasses was to allow it to spread over the rice straw by means of a half-liter can provided with small holes at the bottom. As much as from 0.4 kgm. to 4.0 kgm. of rice straw and from 0.4 kgm. to 3.0 kgm. of molasses were consumed by each animal per day. Sometimes the young animals would not take any of the supplements, but this happened so seldom that their condition was not affected.

Salting and watering

The animals in all the lots drank from the creek in the pasture where they were kept. Each received about a handful of common salt weekly.

Weighing

All the animals were weighed every Sunday afternoon before those in lot I received their supplements. The average weights during the first three consecutive days were taken as the initial weight. The final weight was obtained similarly; that is, the average weight during the last three days was taken.

Plants in the pasture

The predominating species in the pasture were cogon [*Imperata cylindrica* (Linn.) Beauv. var. *koenigii* (Retz.) Benth.], which constituted approximately 35 per cent of all vegetation there suitable for feeding purposes, and about equal amounts of Bermuda grass [*Cynodon dactylon* (Linn.) Pers.], paragis [*Eleusine indica* (Linn.) Gaertn.] and kulape (*Paspalum conjugatum* Berg.). The remainder of the plant feed in the pasture was *Panicum flavidum* Retz.

The weeds which encroached on the stand of the grass in the order of their prevalence were: magilik (*Premna cumingiana* Schauer), sambong [*Blumea balsamifera* (Linn.) DC.], payang-payang [*Flemingia strobilifera* (Linn.) R. Br.], balatong aso (*Cassia tora* Linn.), *Callicarpa formosana* Rolfe, and *Blumea* sp.

Determination of the stand of grass

Six quadrates of one meter square were located at various points in the pasture to determine the stand of cogon. The heights of ten cogon plants in the quadrates were measured every two weeks. As the stakes marking the quadrates were near the ground, the plants in all of them were accessible to the animals.

RESULTS AND DISCUSSION

Dry season

The dry season in this work covers a period of 112 days, from March 1, 1936, to June 21, 1936. It is equivalent to four 4-week periods.

Amount and cost of molasses consumed. Table 2 shows the amount of the supplements consumed by the animals. From this table, it will be seen that the average consumption of molasses during the dry season for a period of 4 weeks was from 29.26 kgm. to 50.67 kgm. Thus the average daily consumption was from 1.045 to 1.810 kgm. a head. The daily consumption of the animals per 100 kgm. live weight was from 0.386 to 0.665 kgm. of the supplement.

The average cost of molasses consumed by an animal for a period of four weeks ranged from ₱0.265 to ₱0.456. The average daily cost of molasses eaten by each animal during the four periods was from ₱0.009 to ₱0.016.

Amount and cost of rice straw consumed. It will be seen in table 2 that the average consumption of rice straw for a period of four weeks varied from 17.46 kgm. to 22.21 kgm. a head. Accordingly, the average daily consumption a head was from 0.624 to 0.793 kgm. The consumption per 100 kgm. live weight was from 0.224 to 0.267 kgm.

The cost of rice straw consumed by the animals for four weeks was from ₱0.140 to ₱0.177. It follows that the average daily cost of rice straw consumed by each animal was from ₱0.005 to ₱0.006.

Weight of animals. Table 3 shows the weights of the animals taken at intervals of four weeks. By reference to this table, it will be seen that while all the animals in lot I, with the exception of two, decreased in weight at the end of the second 4-week period, all of them increased in weight by the end of the dry season. The average increase a head was 29.43 kgm.

In lot II, at the end of the dry season period, three increased in weight, the other three cows decreased. The increases were made by the younger animals and the decreases, by the much older ones. Based on the average for the animals in this lot, the gain in weight was 1.43 kgm. a head.

This may be expected because, whereas lot I animals received supplements aside from the pasture feeds, lot II animals depended for their subsistence entirely on the pasture grass which was insufficient during the dry season.

Wet season

The wet season in this study covered a period of 196 days, from June 22, 1936, to January 3, 1937. It is equivalent to seven 4-week periods.

Amount and cost of molasses consumed. Table 4 shows the consumption of molasses during the wet season. It will be seen in this table that the average consumption of molasses by the animals varied from 25.93 kgm. to 43.08 kgm. a head for four weeks, or an average daily consumption of from 0.926 kgm. to 1.539 kgm. a head. The average daily consumption of molasses per 100 kgm. live weight during the wet season ranged from 0.335 kgm. to 0.542 kgm.

The average cost of molasses consumed by each animal varied from ₱0.234 to ₱0.388 for four weeks. Accordingly, the average cost for each animal a day was from ₱0.008 to ₱0.014.

Amount and cost of rice straw. Table 4 also shows the consumption of rice straw by the animals. From this table, it will be noted that the average consumption varied from 21.74 to 49.23 kgm. a head for four weeks. The average daily consumption by each animal, therefore, was from 0.776 to 1.758 kgm. The consumption per 100 kgm. live weight ranged from 0.287 to 0.606 kgm. daily.

The average cost of rice straw consumed by each animal for a period of four weeks ranged from ₱0.174 to ₱0.407. The average daily cost was from ₱0.006 to ₱0.015.

Weight of animals. Table 5 shows the weights of animals at the end of each 4-week period. From this table, it will be noted that in lot I all animals, with the exception of No. 258, registered losses in weight at various periods. At the end of the experiment, however, all animals increased in weight with the exception of No. 233 which appeared very emaciated. Notwithstanding this, the average increase in weight for lot I was 19.93 kgm.

Lot II animals registered losses in weight between periods. At the end of the experiment, however, all the animals with the exception of No. 182 and No. 220, increased in weight with an average for the lot of 16.45 kgm. If this average increase in weight per animal in lot II is compared with that in lot I, the difference is only 3.48 kgm.

The general tendency of the rate of increase in weight of the animals in both lots was similar, although the animals in lot I weighed more at the end of the experiment than those in lot II. This may be accounted for by the fact that the animals in lot I had the advantage of starting with higher average weights at the beginning of the second part of the experiment, owing to the favorable effect of supplemental feeding upon them during the preceding dry season.

The smaller difference in the rate of increase in weight between lots I and II in the wet-season period as compared with that of the dry-season period may be accounted for by the better growth of the grass in the pasture during the rainy season. This suggests that feeding of supplements is more necessary during the dry season than during the wet season.

Height of cogon

The height of cogon taken at 2-week intervals in the quadrates showed that the average height of cogon ranged from 18.48 centimeters to 33.03 centimeters. The former was recorded during the dry season and the latter during the rainy season. As previously mentioned, these quadrates were accessible to the animals at all times.

SUMMARY AND CONCLUSIONS

The study herein reported is a feeding experiment in which molasses and rice straw were used as supplements to pasture feeds for range cattle. During the dry season, the feeding period lasted 112 days, from March 1, to June 21, 1936, whereas during the wet season, it lasted 196 days, from June 22, 1936, to January 3, 1937.

Two lots of six cows each were used in this work. Animals in lot I were given rice straw and molasses in addition to pasture feeds, whereas those in lot II had access to pasture feeds only, at all times.

The predominating species of useful vegetation consisted of approximately 35 per cent cogon [*Imperata cylindrica* (Linn.) Beauv. var. *koenigii* (Retz.) Benth.], and about equal amounts of Bermuda grass [*Cynodon dactylon* (Linn.) Pers.], paragis [*Eleusine indica* (Linn.) Gaertn.], and kulape (*Paspalum conjugatum* Berg.). The weeds were magilik (*Premna cumingiana* Schauer), sambong [*Blumea balsamifera* (Linn.) DC.], balatong aso (*Cassia tora* Linn.), *Callicarpa formosana* Rolfe, and *Blumea* sp.

The following results were obtained from this study:

1. The average amount of the supplements consumed by the animals during the dry season ranged from 1.045 to 1.810 kgm. of molasses and from 0.624 to 0.793 kgm. rice straw a head daily.

2. The average daily consumption of molasses per 100 kilogram live weight ranged from 0.386 to 0.665 kgm. and of rice straw from 0.224 to 0.267 kgm.

3. On the average, the daily cost of the supplements consumed by each animal during the dry season period ranged from ₱0.009 to ₱0.016 for molasses and from ₱0.005 to ₱0.006 for rice straw.

4. The average gain in weight a head at the end of the feeding period during the dry season was 29.43 kgm. for animals in lot I, and 1.43 kgm. for those in lot II. A difference of 28.0 kgm. in favor of the animals in lot I resulted.

5. During the wet season, the consumption of molasses was from 0.926 to 1.539 kgm. and of rice straw from 0.776 to 1.758 kgm. a head daily.

6. The average daily consumption of molasses per 100 kgm. live weight ranged from 0.335 to 0.542 and of rice straw from 0.287 to 0.606 kgm.

7. The average cost of the supplements consumed during the wet season ranged from ₱0.008 to ₱0.014 for molasses, and ₱0.006 to ₱0.015 for rice straw a head daily.

8. The average gain in weight per head of the animals at the end of the 196 days feeding period during the wet season was 19.93 kgm. in lot I and 16.45 kgm. in lot II or a difference of 3.48 kgm. in favor of the animals in lot I.

9. Based on the gains in weight made by the animals during the dry and wet seasons, it is evident that the supplements had a much more favorable effect on the condition of the animals during the dry season than during the wet season. The advantage derived from supplementing the pasture during the wet season was so little that it did not pay.

10. The average height of cogon recorded throughout the experimental period taken at intervals of two weeks ranged from 18.48 cm. during the dry season to 33.03 cm. during the wet season.

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TABLE 1

The proximate analysis of rice straw and molasses[a]

	MOLASSES			RICE STRAW
	C. S. E.[b]	P. S. E. D.[c]	Average	
	per cent	*per cent*	*per cent*	*per cent*
Moisture	35.68	36.03	35.855	9.52
Proteins	1.22	1.85	1.535	3.16
Fat (Ether extract)	0.26	0.06	0.160	1.15
Crude fiber	—	—	—	30.08
Nitrogen-free extract	54.01	51.56	52.785	36.97
Ash	8.83	10.50	9.665	19.12
Calories per 100 grams	229.00	220.00	224.500	175.00
Specific gravity at room temperature		1.4545	1.4545	—

[a] Analyzed in the Department of Agricultural Chemistry, College of Agriculture, University of the Philippines.

[b] Calamba Sugar Estate.

[c] The Philippine Sugar Estates Development Co.

TABLE 2

The consumption of rice straw and molasses by the animals at 4-week intervals during the 112-day feeding period in the dry season

ANIMAL NUMBER	FIRST PERIOD		SECOND PERIOD		THIRD PERIOD		FOURTH PERIOD	
	Rice straw	Molasses	Rice straw	Molasses	Rice straw	Molasses	Rice straw	Molasses
	kgm.	*kgm.*	*kgm.*	*kgm.*	*kgm.*	*kgm.*	*kgm.*	*kgm.*
110	33.60	53.20	37.65	82.40	35.83	80.00	49.92	73.60
185	24.04	39.60	23.59	56.00	24.49	56.80	28.12	52.80
205	10.87	19.20	12.25	37.60	11.34	47.20	13.61	30.40
258	12.25	20.40	13.61	39.20	10.43	38.40	14.97	30.40
261	12.70	21.60	14.51	39.60	11.79	40.80	13.15	30.40
265	12.70	21.60	13.15	40.00	10.89	40.80	13.50	29.60
Average	17.69	29.26	19.13	49.13	17.46	50.67	22.21	41.20
Average daily consumption	0.632	1.045	0.683	1.755	0.624	1.810	0.793	1.471

TABLE 3

The weights of the animals at the end of 4-week intervals during the 112-day feeding period in the dry season

LOT I (WITH SUPPLEMENT)

ANIMAL NUMBER	INITIAL WEIGHT	END OF FIRST PERIOD		END OF SECOND PERIOD		END OF THIRD PERIOD		END OF FOURTH PERIOD		GAIN OR LOSS AT THE END OF 112 DAYS
		Weight	Gain or loss	Weight	Gain or loss	Weight	Gain or loss	Weight	Gain or loss	
	kgm.	*kgm.*	*kgm.*	*kgm.*	*kgm.*	*kgm.*	*kgm.*	*kgm.*	*kgm.*	*kgm.*
110	366.5	398.3	31.8	399.6	1.3	414.1	14.5	415.5	1.4	49.0
185	278.1	298.9	20.8	289.8	— 9.1	293.9	4.1	299.4	5.5	21.3
205	251.3	248.6	— 2.7	235.0	—13.6	255.8	20.8	262.2	6.4	10.9
258	194.0	211.8	18.1	208.2	— 3.6	212.3	4.1	226.8	14.5	33.1
261	223.2	242.2	19.0	228.6	—13.6	245.9	17.3	245.9		22.7
265	197.3	211.4	14.1	215.9	4.5	217.7	1.8	237.2	19.5	39.9
Average	251.72	268.53	16.80	262.85	— 5.68	273.28	10.43	281.16	7.88	29.43

LOT II (WITHOUT SUPPLEMENT)

ANIMAL NUMBER	INITIAL WEIGHT	END OF FIRST PERIOD		END OF SECOND PERIOD		END OF THIRD PERIOD		END OF FOURTH PERIOD		GAIN OR LOSS AT THE END OF 112 DAYS
		Weight	Gain or loss	Weight	Gain or loss	Weight	Gain or loss	Weight	Gain or loss	
88	338.4	327.5	—10.9	328.0	0.5	332.9	4.9	326.6	— 6.3	—11.8
182	318.0	306.6	—11.4	299.4	— 7.2	305.3	5.9	296.7	— 8.6	—21.3
220	262.6	269.4	6.8	244.9	—24.9	256.7	11.8	260.3	3.6	— 2.3
252	225.0	238.1	13.1	230.0	— 8.1	228.6	— 1.4	234.1	5.5	9.1
264	183.3	198.7	15.4	200.0	1.3	198.7	— 1.3	198.7		15.4
269	182.8	196.0	13.2	196.0		187.3	— 8.7	202.3	15.0	19.5
Average	251.68	256.05	4.37	259.71	— 3.66	251.58	— 8.13	253.11	1.53	1.43

TABLE 4

The consumption of rice straw and molasses at 4-week intervals during 196-day feeding period in the wet season

ANLMAL NUMBER	FIRST PERIOD		SECOND PERIOD		THIRD PERIOD		FOURTH PERIOD		FIFTH PERIOD		SIXTH PERIOD		SEVENTH PERIOD	
	Rice straw	Molasses	Rice straw	Molasses	Rice straw	Molasses	Rice straw	Molasses	Rice straw	Molasses	Rice straw	Molasses	Rice straw	Molasses
	kgm.	*kgm.*	*kgm.*	*kgm.*	*kgm.*	*kgm.*	*kgm.*	*kgm.*	*kgm.*	*kgm.*	*kgm.*	*kgm.*	*kgm.*	*kgm.*
185	33.43	50.40	47.00	43.20	50.60	33.60	55.20	33.60	64.80	43.60	81.60	47.60	65.00	53.20
205	18.90	27.60	26.80	23.20	18.40	22.00	22.40	24.40	28.00	34.80	46.00	35.20	33.80	37.60
233	32.83	45.60	45.70	38.40	38.00	30.40	52.00	32.00	61.20	47.20	72.60	46.00	55.00	44.80
258	15.35	24.80	24.50	19.60	18.00	22.00	18.00	22.40	25.20	32.00	28.40	34.72	23.20	41.50
261	13.37	24.80	23.80	22.00	20.80	24.40	21.60	23.60	26.80	35.20	40.40	36.00	31.20	33.00
265	16.55	26.80	20.20	18.80	19.20	23.20	28.60	31.20	27.20	37.20	26.40	41.60	29.60	48.40
Average	21.74	33.33	31.33	27.53	27.50	25.93	32.97	27.87	38.87	38.33	49.23	40.19	39.63	43.08
Average daily consumption	0.776	1.190	1.119	0.983	0.982	0.926	1.178	0.995	1.388	1.369	1.758	1.435	1.415	1.539

TABLE 5

The weights of the animals at the end of 4-week intervals during the 196-day feeding period in the wet season

LOT I (WITH SUPPLEMENTS)

ANIMAL NUMBER	INITIAL WEIGHT	END OF FIRST PERIOD		END OF SECOND PERIOD		END OF THIRD PERIOD		END OF FOURTH PERIOD	
		Weight	Gain or loss	Weight	Gain or loss	Weight	Gain or loss	Weight	Gain or loss
	kgm.	*kgm.*	*kgm.*	*kgm.*	*kgm.*	*kgm.*	*kgm.*	*kgm.*	*kgm.*
185	299.4	311.2	11.8	303.0	—8.2	309.4	6.4	310.3	0.9
205	262.2	273.1	10.9	261.3	—11.8	285.3	24.0	291.2	5.9
233	308.0	286.7	—21.3	277.6	—9.1	285.8	8.2	291.2	5.4
258	226.8	243.1	16.3	244.5	1.4	253.8	9.3	266.7	12.9
261	245.9	269.4	23.5	272.2	2.8	275.8	3.6	271.3	—4.5
265	237.2	233.2	—4.0	241.3	8.2	251.7	10.4	258.6	6.9
Average	263.25	269.45	6.2	266.65	—2.8	276.96	10.31	281.55	4.59

LOT II (WITHOUT SUPPLEMENTS)

ANIMAL NUMBER	INITIAL WEIGHT	END OF FIRST PERIOD		END OF SECOND PERIOD		END OF THIRD PERIOD		END OF FOURTH PERIOD	
182	296.7	308.4	11.7	320.2	11.8	328.4	8.2	328.4	—
220	260.3	263.1	2.8	274.0	10.9	274.4	0.4	268.5	—5.9
225	240.9	249.5	8.6	245.9	—3.6	253.1	7.2	257.6	4.5
252	234.1	247.7	13.6	247.7	—	268.5	20.8	261.3	—7.2
264	198.7	215.9	17.2	224.1	8.2	228.6	4.5	233.6	5.0
269	202.3	222.3	20.0	235.0	12.7	250.4	15.4	240.0	—10.4
Average	238.83	251.15	12.32	257.81	6.66	267.23	9.42	264.9	—2.33

TABLE 5 (continued)

LOT I (WITH SUPPLEMENTS)

ANIMAL NUMBER	INITIAL WEIGHT	END OF FIFTH PERIOD		END OF SIXTH PERIOD		END OF SEVENTH PERIOD		GAIN OR LOSS AT THE END OF THE EXPERIMENT
		Weight	Gain or loss	Weight	Gain or loss	Weight	Gain or loss	
	kgm.	*kgm.*	*kgm.*	*kgm.*	*kgm.*	*kgm.*	*kgm.*	*kgm.*
185	299.4	313.0	2.7	318.4	5.4	314.8	—3.6	15.4
205	262.2	291.2	—	280.8	—10.4	279.4	—1.4	17.2
233	308.0	285.8	—5.4	277.1	—8.7	276.2	—0.9	—31.8
258	226.8	273.1	6.4	275.8	2.7	284.4	8.6	57.6
261	245.9	281.2	9.9	284.9	3.7	281.2	—3.7	35.3
265	237.2	262.2	3.6	264.4	2.2	263.1	—1.3	25.9
Average	263.25	284.41	2.86	283.56	0.85	283.18	—0.38	19.93
LOT II (WITHOUT SUPPLEMENTS)								
182	296.7	329.7	1.3	333.8	—5.9	294.4	—39.4	—2.3
220	260.3	273.1	4.6	266.7	—6.4	253.1	—13.6	—7.2
225	240.9	266.3	8.7	263.1	—3.2	257.2	—5.9	16.3
252	234.1	270.3	9.0	258.1	—12.2	251.7	—6.4	17.6
264	198.7	240.9	7.3	238.6	—2.3	232.2	—6.4	33.5
269	202.3	247.7	7.7	245.4	—2.3	243.1	—2.3	40.8
Average	238.83	271.33	6.43	267.61	—5.39	255.28	—12.33	16.45

A COMPARATIVE STUDY ON THE FORAGE AND WATER CONSUMPTION OF SHEEP AND GOATS[1]

PEDRO P. ASUNCION

It is generally believed that sheep and goats will eat and relish almost all classes of weeds and brush. However, for successful sheep and goat raising such plants can not be depended upon entirely for supply of forage. Sheep and goats respond favorably to intelligent care and good feeding and, if wholesome feeds are supplied, good results may be expected.

The study here presented was undertaken to find out the amount of forage and water sheep and goats would consume daily. Such data are useful not only in determining the carrying capacity of pastures for these animals but also for enabling feeders to set aside enough feed for them. It is important also to know the comparative amount of water that a sheep or goat will drink when supplied liberally. This is of interest in view of the common belief that goats can thrive in pastures lacking in water supply.

Suratos (1933) conducted experiments on the palatability of some Philippine plants for goats. He found that for mature goats using feed in the form of soilage the average consumption from 6:00 a.m. to 1:00 p.m. per head was as follows: Corn forage, 2.35 kgm.; napier grass, 2.19 kgm.; guinea grass, 1.82 kgm.; *Digitaria corymbosa*, 1.82 kgm.; sweet potato vine, 1.62 kgm.; *Operculina turpethum*, 1.55 kgm.; madre de cacao, 1.27 kgm.; saguing butuan, 1.25 kgm.; sugar cane tops, 1.07 kgm.; cogon, 1.03 kgm.; ipil-ipil, 1.01 kgm.

Shaw (1913) states that as a general rule from 2 to 4 pounds (0.90-1.81 kgm.) per head a day is considered as much as should be fed to sheep.

According to Coffey (1918), lambs receiving nothing but dry feeds in cold weather will drink a half-gallon (1.89 liters) daily and on warm days much more.

According to Henry and Morrison (1929), opinions as to the water requirement of sheep vary more than with any other domestic animal. In countries with heavy dew and ample succulent feed in summer, and where roots are largely used in winter, water may possibly be denied sheep but ordinarily it is a necessity. They further state that on the arid ranges of the southwest of the United States, when grazing on certain succulent plants, sheep sometimes go for months without drinking. But under usual conditions, it is recommended that sheep be supplied from 1 to 6 quarts (0.95 to 5.68 liters) daily.

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[1] Experiment Station contribution No. 1329. Prepared in the Department of Animal Husbandry under the direction of Associate Professor Valente Villegas.

Goats are noted, according to Richards (1921), for the small amount of water that they seem to require in a state of nature. He recommends that for heavy production of milk every effort should be made to induce the doe to drink.

This work was undertaken with the following objects: (*a*) to find out the comparative forage and water consumption of sheep and goats, and (*b*) to determine the relationship between the amount of forage consumed and the weight of sheep and goats.

This experiment was conducted in the Department of Animal Husbandry, College of Agriculture, from January, 1933, to January, 1934, covering a period of exactly one year.

Animals

In this experiment seven full-grown Indian grade sheep and seven Anglo-Nubian grade goats of similar development were used. In both sets of animals there was one male. The sheep ranged in age from one year and nine months to eleven years and nine months, the average age being six years and one month. The age of the goats varied from two years and six months to seven years and three months, the average age being five years and one month. The average weight of the sheep was 32.54 kgm., the range being from 22.89 to 50.82 kgm. The goats varied in weight from 29.13 to 43.75 kgm., with an average of 36.59 kgm.

Forages

The forage used was napier grass (*Pennisetum purpureum* Schum.) and corn silage. Napier grass was given in the form of soilage and was cut just before the flowering stage. Before being fed to the animals, it was cut into 10-cm. lengths.

Water

The drinking water furnished to the animals was ordinary tap water.

Stalls

Stalls for the feeding experiment were specially constructed and partitioned so as to separate the animals. Stanchions by which the animals were kept in place during the feeding period were provided in front of each stall. Also, in front of the stalls was built a common trough in which the feed was placed at feeding time. Partitions were constructed in such a way as to separate the feed of one animal from that of another.

Feeding and watering

During the feeding period the animals were put in their stalls in the morning at six o'clock. They were each fed full and watered three times during the day, at 6:00 a.m., 11:00-11:30 a.m., and 5:30-6:00 p.m., after which they were returned to the barn for the night.

When feed was scarce the feeding period lasted for only five days at a time. Twice, the feeding and watering period was extended to ten days when feed was abundant. Efforts were made to distribute the feeding and watering periods uniformly throughout the year. Altogether, the animals were fed soilage for a period of 50 days and silage for 30 days. Water was given at the same time that the animals were given soilage and silage.

Weighing of the animals

The weights of the animals were taken once a month throughout the experiment.

Recording

Records of the feed and water consumed were taken. The forage consumption of each animal was determined by substracting the weight of the left-over from the total weight of the forage given during the whole day. In the case of water, direct readings were taken of the weight of the water before and after each animal was watered, the difference being the quantity of water consumed.

DISCUSSION OF RESULTS

Soilage consumption

The range in quantity of soilage taken by ewes per head daily was from 3.33 ± 0.11 kgm. for sheep No. 63 to 5.64 ± 0.18 kgm. for sheep No. 79. With all the ewes taken together, the mean amount eaten daily by one animal was 3.94 ± 0.09 kgm. The mean consumption by ram No. 52 was 5.62 ± 0.19 kgm. The difference, therefore, in favor of the ram is significant.

With does, the average daily soilage consumption varied from 3.17 ± 0.15 kgm. by goat No. 144 to 4.10 ± 0.16 kgm. by animal No. 173. The mean amount of soilage consumed daily by one doe was 3.69 ± 0.08 kgm. The mean daily soilage consumption by buck No. 304 was 4.32 ± 0.24 kgm. The difference between the consumption of the does and that of the buck was insignificant.

The difference between the soilage consumption of the ram and that of the buck is significant, in favor of the ram, whereas the difference between the consumption of the female sheep and goats was not significant.

Relation between the consumption of soilage and live weight of animal

With ewes, the daily consumption of soilage varied from 11.01 to 15.53 kgm. per 100 kgm. of the live weight of the animal, the average being 13.60 kgm. The daily consumption of the ram was 11.05 kgm.

With does, the soilage consumption in relation to the live weight of the animal varied from 8.57 to 12.83 kgm. per 100 kgm. of the live weight of the animals, the average being 9.85 kgm. In the case of the buck, the ratio was 14.35 kgm. per 100 kgm. of the live weight of the animal.

Water consumption

Sheep and goats drank several times during a period of fifty test days, in agreement with the statement of Henry and Morrison (1929) that sheep grazing on succulent plants in the arid ranges of the southwest of the United States sometimes go for two months without drinking.

Ewes Nos. 13, 57, and 63 took water only one day during the investigation, while No. 2 drank during 16 days and No. 79 during 13 days, the average being 6.4 days, or 12.8 per cent of the watering period. They drank from 90 to 513.3 cc., the average being 269 cc. a head daily. The ram, No. 52, drank an amount of 2,267 cc. on one day only, or 2.0 per cent of the watering period.

Does Nos. 144 and 173 drank on one day only, No. 195 on two days, No. 231 on six days and No. 203 on 11 days, the average being 4.2 days during the investigation, or 8.4 per cent of the watering period. The range in the amount of water taken by the does was from 45 to 354.2 cc. the average being 138.5 cc. a head daily. The buck drank on 9 days, or 18.0 per cent, of the watering period. He took an average of 286.9 cc. a day.

Silage consumption

The amount of silage consumed by the ewes ranged from 1.71 ± 0.22 kgm. with animal No. 63 to 3.08 ± 0.28 kgm. with sheep Nos. 3 and 79, the mean daily consumption of all being 2.24 ± 0.14 kgm. a head. The ram, No. 52, consumed 3.48 ± 0.21 kgm. a day.

With does Nos. 173, 195, 203, 231, 281, the daily consumption of silage varied from 1.98 ± 0.27 kgm. in the case of Nos. 231 and 281 to 2.83 ± 0.17 kgm. in the case of No. 173, the mean for these five does being 2.50 ± 0.16 kgm. a head. Doe No. 144 took abnormally small amounts of silage throughout the test, the mean being 0.30 ± 0.29 kgm. Hence, its consumption was not included in the mean for the does. The buck, No. 304, consumed 2.71 ± 0.29 kgm. a day. The difference in silage consumption by the does and the buck was insignificant.

Likewise, there was an insignificant difference between the consumption of silage by the ram and buck as well as by ewes and does.

Relation between silage consumption and weight of animals

The range in silage consumption was from 6.66 to 9.52 kgm. per 100 kgm. of the live weight of the ewes, the average being 7.83 kgm. With the ram the consumption was 6.84 kgm. per 100 kgm. of its live weight.

In does Nos. 173, 195, 203, 231, and 281 the silage consumption varied from 5.53 to 6.85 kgm. per 100 kgm. live weight, the average being 6.32 kgm. The amount of silage consumed by No. 144 in relation to its live weight is not included in the average owing to the extraordinarily low amounts of silage this doe took during the investigation. The amount of silage taken by the buck was 9.00 kgm. per 100 kgm. of its live weight.

Water consumption

The amount of water consumed by sheep and goats when fed silage was much more than when fed soilage. The ewes drank on an average of 15.8 days (52.7 per cent) out of a total of 30 days' test period. Ewe No. 63 took water the least number of days, or 7 days, and ewe No. 3, the greatest number, or 24 days. The ram, No. 52, drank on 13 days (43.3 per cent). Ewe No. 2 took the lowest amount of water, the average being 477.2 cc. a day, while ewe No. 3 drank the largest amount, or an average of 1,095.7 cc. a day. The ram, No. 52, took an average of 512.2 cc. a day.

The does drank on an average of 12.6 days (42.0 per cent) in 30 days' test period. Doe No. 203 drank the least number of times, or 11 days, and doe No. 231, the greatest number, or 14 days. Buck No. 304 took water in 20 days (66.7 per cent) during the test period. The minimum amount of water taken daily was 300.5 cc. by doe No. 203 and the maximum amount, 783.4 cc., by doe No. 195, the average being 454.3 cc. a head. The buck drank 481.5 cc. a day.

SUMMARY AND CONCLUSIONS

The following is a summary of the work herein presented:

1. A comparative study of the forage and water consumption of sheep and goats was determined with the use of grade Indian sheep and grade Anglo-Nubian goats. For forages, napier grass as soilage and corn silage were used.

2. The mean daily soilage and silage consumption by sheep and goats follows:

	Soilage *kgm.*	*Silage* *kgm.*
Ewe	3.94 ± 0.09	2.24 ± 0.14
Ram	5.62 ± 0.19	3.48 ± 0.21
Doe	3.69 ± 0.08	2.50 ± 0.16
Buck	4.32 ± 0.24	2.71 ± 0.29

3. The difference between the amount of soilage and silage consumed by ewes and the ram was significant, in favor of the ram. On the other hand, there was no significant difference between the amount of both feeds taken by the does and by the buck.

4. If the amount of soilage consumed by the ewes and does, is compared, the difference is insignificant. The same is true of silage. Between the ram and buck, the amount of soilage taken by the former was significantly greater than that consumed by the latter. There was, however, no significant difference in the silage consumption by the ram and buck.

5. The average amount of soilage and silage consumed by sheep and goats per 100 kgm. of their live weight follows:

	Soilage *kgm.*	*Silage* *kgm.*
Ewe	13.60	7.83
Ram	11.05	6.84
Doe	9.85	6.32
Buck	14.35	9.00

6. Sheep and goats drank much lower amounts of water when fed soilage than when fed silage.

7. The ewes drank on an average of 12.8 per cent of the number of days that water was offered to them when fed soilage, and the ram only 2.0 per cent of this time. The average amount of water taken by the ewes was 269.1 cc. per head daily, and by the ram 2,267.0 cc. The does drank on an average of 8.4 per cent of the number of days they were watered when fed the same feed, and the buck 18.0 per cent. The average amount of water consumed by the does was 138.5 cc. and that by the buck 286.9 cc.

8. When fed silage, the ewes drank on 52.7 per cent of the days they were watered, the amount of water taken by each being 710.8 cc. daily. The ram drank on 43.3 per cent of the days and took 512.2 cc. a day. The does on the same feed drank on 42.0 per cent of the days and consumed an average of 454.3 cc. a day. The buck drank on 66.7 per cent of the days and took 481.5 cc. a day.

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STUDIES ON DIFFERENT CONTAINERS FOR POTTING FRUIT PLANTS[1]

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WITH TWO TEXT FIGURES

Coconut husks are often used for potting ornamental plants, especially aërial plants; either shredded or whole, they are also used for marcotting fruit plants. The coconut husk, however, has never been utilized in nurseries for potting terrestrial or fruit plants.

Bamboo tubes or joints are also often used not only for potting seedlings but also for marcotting fruit plants. Since coconut husks and bamboos are readily available in many parts of the Philippines, it will be of interest to find their merits compared with earthen pots; hence the present study was conducted.

The object of this study was to determine the adaptability of different materials for potting fruit plants.

This work was conducted from June, 1937, to August, 1939, on Faculty Hill and in a nursery of the Department of Agronomy, College of Agriculture.

MATERIALS AND METHODS

Materials

Pots. Four different kinds of containers were used, namely, earthen pot, coconut husk, tin can, and bamboo joint. Earthen pot No. 4 was used with the following inside dimensions: height, 14 cm.; top diameter, 17.5 cm.; and bottom diameter, 11 cm.

Each coconut husk pot was made by fastening together pieces of the husk with a piece of No. 20 wire.

A "Magnolia" can which was cylindrical in form was used and had a height of 21 cm. and a diameter of 15 cm.

The bamboo pots were made by dividing a regular sized bamboo into pieces with one joint and a lower node. A hole about one centimeter in diameter was made at the bottom of each joint to serve as drainage.

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[1] Experiment Station contribution No. 1330. Read before the Los Baños Biological Club on August 31, 1939. The writer wishes to express his obligation to Dr. Leon G. Gonzalez for supplying some of the seedlings used in the experiment and for his valuable suggestions.

Planting materials. Seedlings of the following fruit trees were used: avocado (*Persea americana* Mill.), calamondin (*Citrus microcarpa* Bunge), chico (*Achras zapota* Linn.), santol [*Sandoricum koetjape* (Burm. f.) Merr.], and star apple (*Chrysophyllum cainito* Linn.). Avocado, santol, and starapple are typical of fast growing fruit plants. Calamondin and chico represent the slow growing type. From 30 to 50 seedlings were used in the study of each kind of pot.

Soil. The soil medium used was a mixture of two parts clay loam soil and one part of decayed horse manure.

Methods

Experiment 1. Determination of comparative vigor of plants in coconut husks and those planted directly in the ground. In this preliminary experiment, apparently uniform seedlings of avocado and chico were used. The seedlings were divided into two lots. In one lot the seedlings were each potted in a coconut husk. The rest of the seedlings were planted directly in the ground 30 to 50 cm. apart in nursery rows. The coconut husks were buried in the ground side by side with the seedlings planted in nursery rows.

After eight months when the seedlings were ready for inarching, the comparative vigor of the plants planted directly in the ground and those in coconut husks was observed.

Inarching the plants. That the adaptability of the different pots as containers of seedlings for inarching or grafting by approach might be studied, the seedlings that were planted directly in the ground were balled and potted in coconut husks, earthen pots, and cans. Likewise, the seedlings potted in buried coconut husks were dug up. The seedlings were then inarched and the comparative adaptability of the different containers when used as pots for seedlings inarched to trees at varying heights was particularly noted.

Experiment 2. Study of comparative vigor of plants in partially and fully buried coconut husks. Because it was found in a preliminary experiment that, when buried, some of the coconut husks were partly eaten by white ants or partly decayed, this experiment was conducted to find the effect of exposing the husks, on the vigor of the plants and the decomposition of the husks.

One hundred apparently uniform seedlings of avocado were selected and each potted in a coconut husk. They were then divided into two lots; in one lot the husks were fully buried in the ground and in the other lot the husks were partially buried just deep enough to prevent them from falling apart and from rotting. When the plants were ready for inarching, their height was recorded separately. The general appearance of the plants under each treatment was also observed.

Experiment 3. Study of comparative vigor of plants potted in different containers. Three different kinds of pots namely, earthen pots, coconut husks, and bamboo pots were used. Apparently uniform seedlings of each of the following fruit plants were used: calamondin, chico, santol, and star apple. The seedlings were each potted in each of the different potting materials which contained practically the same amount of soil medium. The three different kinds of pots were then placed in the shade side by side in the nursery. The bamboo pots were supported by two parallel pieces of bamboo tied to pegs to prevent them from falling. The coconut husks were partly buried in the ground to prevent them from falling apart. The plants were given the usual nursery care. They were observed from time to time and at the end of the experiment or after about twelve months, the height and diameter of each plant were recorded. Likewise, the general appearance of the plants under the different treatments was observed. The different containers were observed for the degree of deterioration and the attack of white ants.

RESULTS AND DISCUSSIONS

Experiment 1. Comparative vigor of plants potted in coconut husks and those planted directly in the ground. The results of the preliminary experiment showed that after eight months the plants in buried coconut husks had practically the same vegetative vigor as those planted directly in the ground. The dug-up potted plants were just as normal as the balled plants. It was also observed that it took less effort and time to dig up the potted plants than to ball those planted directly in the ground. The result of this experiment is of special interest to nurserymen as the use of coconut husks in the nursery may save labor, time, and, hence, money.

It was observed that some of the buried coconut husks were partly eaten by white ants and some were partly decayed; hence, it was hard to keep the husks together when they were dug up. However, this was done by wrapping each with a piece of old gunny sack as may be seen in figure 1.

In figure 1 may be seen the seedlings in different containers ready for inarching. Of the three different containers used, namely, coconut husk, earthen pot and can, the coconut husk was found to be the best. The following are the advantages of coconut husk over the other two kinds of pots as containers of seedlings inarched: (1) it is lighter than an earthen pot; (2) it can be easily hung upon the branches; (3) it can be hung in any position without its soil contents being spilled, whereas, the other two pots must be hung upon the tree in a more or less vertical position so as not to spill their soil contents; (4) it can be easily watered with the use of a rubber hose; and (5) the husk absorbs and retains more moisture than the earthen pot.

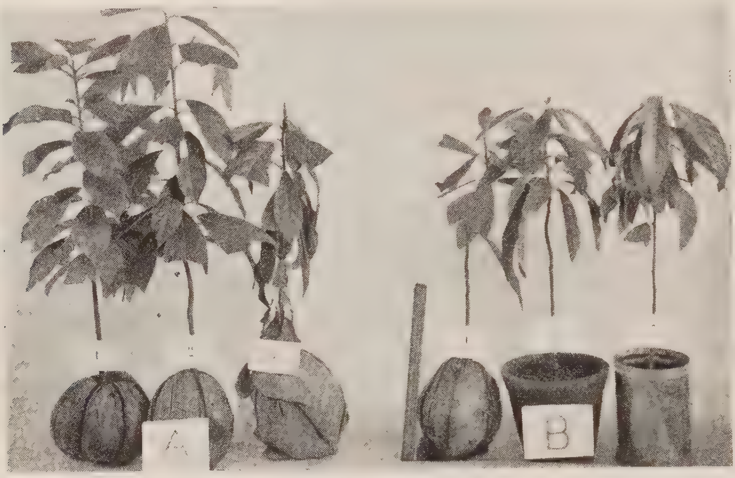

Fig. 1.—Avocado Plants

A. 1. Potted in untied coconut husk buried in the ground.
   2. Potted in coconut husk tied with a piece of wire.
   3. Potted in coconut husk and wrapped with a piece of gunny sack.
B. 1. Planted in nursery row, balled and potted in coconut husk.
   2. Planted in nursery row, balled and potted in an earthen pot.
   3. Planted in nursery row, balled and potted in tin can.

Experiment 2. Comparative vigor of plants in partially and fully buried coconut husks. The results of this experiment are presented in table 1. It will be seen in this table that the plants in coconut husks fully buried in the ground were higher than those in partially buried coconut husks. There was a significant average difference of 7.15 ± 0.89 cm. in the height of the plants. As a whole the plants in fully buried coconut husks were more vigorous than those in partially buried coconut husks. The explanation for this result is that the roots of the plants in fully buried husks were in a more moist and cooler environment since the husks were fully buried in the ground, hence resulting in the more vigorous growth of the plants. It was also observed that more of the buried coconut husks deteriorated than did those partly exposed.

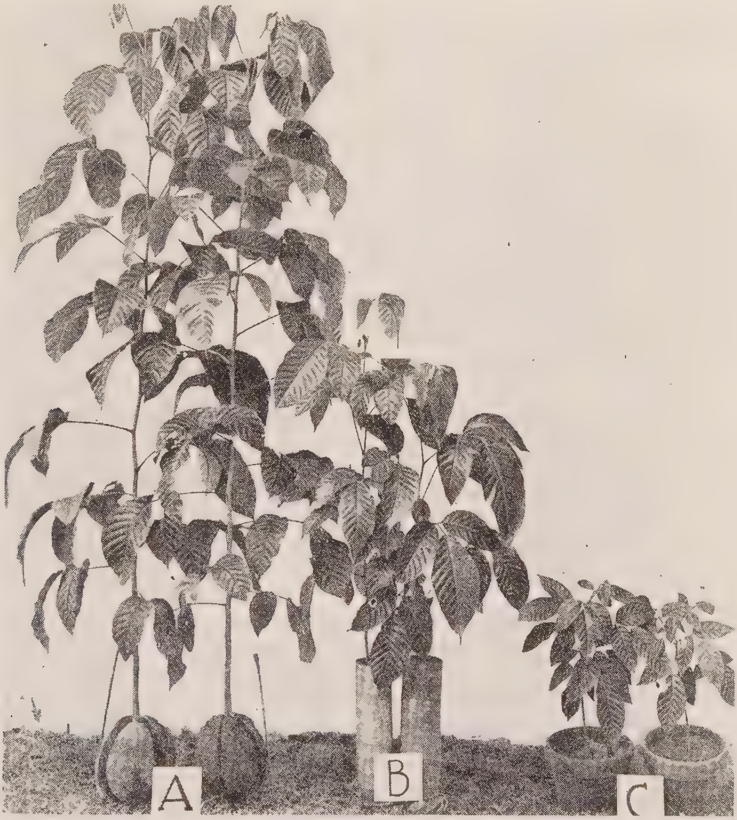

Fig. 2.—Santol plants: A. Potted in partially buried coconut husks. B. Potted in bamboo pots. C. Potted in earthen pots.

Experiment 3. Comparative vigor of plants potted in different containers. The results of this experiment are presented in table 2 and figure 2.

Comparative vigor of calamondin plants. It will be seen in table 2 that the plants potted in coconut husks were the most vigorous and those potted in earthen pots were the least vigorous. The plants potted in coconut husks were higher by an average of 14.57 ± 1.95 cm. and had a larger diameter by an average of 0.15 ± 0.01 cm. than those in earthen pots. Likewise, the plants in bamboo pots were higher by an average of 7.92 ± 1.96 cm. and had a larger diameter by an average of 0.12 ± 0.02 cm. than those in earthen pots. There was no significant difference between the height and diameter of plants potted in coconut husks and those in bamboo pots.

Comparative vigor of chico plants. It will be seen in table 2 that the plants potted in coconut husks were the highest and had the largest diameter. The differences in the height and diameter of the plants potted in coconut husks and those in earthen pots were on the average 10.66 ± 1.56 cm. and 0.07 ± 0.03 cm. respectively. These differences were significant. The plants potted in coconut husks were higher by an average of 15.50 ± 1.86 cm. and were larger in diameter by an average of 0.14 ± 0.03 cm. than those potted in bamboo pots. There was no significant difference between the height and diameter of the plants potted in earthen pots and those potted in bamboo pots.

Comparative vigor of santol plants. It will be seen in table 2 and figure 2 that the plants potted in coconut husks were decidedly the largest and those potted in earthen pots were the smallest. The plants potted in coconut husks were higher by an average of 92.62 ± 2.08 cm. and had an average diameter of 0.70 ± 0.04 cm. more than those potted in earthen pots. There were significant differences of 71.68 ± 2.29 cm. and 0.54 ± 0.05 cm. between the average heights and diameters respectively of plants potted in coconut husks and those in bamboo pots. The plants in bamboo pots had an average height of 20.94 ± 2.24 cm. and an average diameter of 0.16 ± 0.04 cm. more than those potted in earthen pots.

Comparative vigor of star apple plants. It will be seen in table 2 that the plants in coconut husks were significantly higher and had significantly larger diameter than those potted in either earthen or bamboo pots. The differences in the height and diameter of plants potted in coconut husks and those in earthen pots were on the average 43.14 ± 3.52 cm. and 0.23 ± 0.05 cm. respectively. The plants potted in coconut husks were 48.12 ± 3.14 cm. higher and 0.17 ± 0.03 cm. larger in diameter than those potted in bamboo pots. There was no significant difference between the height and diameter of plants potted in earthen and those in bamboo pots.

As a whole the results presented in table 2 show that the plants potted in coconut husks had the best growth. This is very well shown in figure 2. This was especially true of fast growing plants like santol and star apple. The buried coconut husks might have provided a cool medium for the roots of the plants. The luxuriant growth of the plants potted in coconut husks might be due also to the ability of the husk to absorb and retain moisture which was undoubtedly very favorable for the growth of the plants especially in the dry months of summer. Also the decomposing husks might have supplied food elements which favored the rapid development of the plants.

That the calamondin and santol plants potted in bamboo pots were higher and had larger diameter than those in earthen pots may be due to the fact that the bamboo pots were longer and must have been favorable for the vertical growth of the roots of the plants. These two plants have long tap roots and it was found that the tap roots had gone beyond the pots and had penetrated the soil. The shallow earthen pots might have arrested the growth of these tap roots and hence adversely affected the growth of the plants also.

Other observations. With regard to the conditions of the different pots at the end of the experiment, it was found that some of the coconut husks were partly eaten by white ants and some were deteriorating. Under this condition the coconut-husk potted plants could be transplanted in their permanent places in the orchard with the coconut husk buried in the hole. However, if the plants are to be marched the rotten coconut husks must be either wrapped with a piece of old gunny sack or transferred to a new coconut husk.

It was also observed that some of the bamboo pots were eaten by white ants after about twelve months. On the other hand, the earthen pots were not affected by either the white ants or weather conditions. That the earthen pots can be used for a longer period than either coconut husk or bamboo pots is its distinct advantage over the other two pots. However, bamboo pots are cheap and coconut husks can be obtained free.

SUMMARY AND CONCLUSIONS

The results of this study may be summarized as follows:

1. The plants potted in coconut husks fully buried in the ground were just as vigorous as those planted directly in nursery rows. It took a shorter time to remove the potted plants than to ball those directly planted in the ground.

2. The coconut husk was the best potting material especially if the plant was to be inarched. It has the following advantages over the other pots tried: (1) it is lighter than earthen pot; (2) it can be easily hung upon a tree; (3) it can be hung in any position; (4) it is easy to water the plant with the use of a rubber hose; and (5) it absorbs and retains water or moisture.

3. The plants in coconut husks fully buried in the ground were more vigorous than those in partially buried coconut husks.

4. Of the three potting materials tried, coconut husk was the best for it had the most vigorous plants. Bamboo seems to be a better potting material than earthen-ware if the seedlings to be potted have longer tap root like santol.

5. An earthen pot has a distinct advantage over a coconut husk or a bamboo pot in that after a year the last two pots can not be used again while the earthen pot may be used over and over. But bamboo pots are cheap and coconut husks can be obtained free.

TABLE 1

Comparative height of avocado plants in coconut husks under different treatments

TREATMENT	NUMBER OF PLANTS	AVERAGE HEIGHT
		cm.
Coconut husk fully buried in ground	50	36.24 ± 0.77
Coconut husk partially buried in ground	50	29.09 ± 0.44
Difference		7.15 ± 0.89

TABLE 2

Comparative vigor of different kinds of plants under different treatments

KIND OF PLANT	KIND OF POT	NUMBER OF PLANTS	AVERAGE HEIGHT	AVERAGE DIAMETER
			cm.	*cm.*
Calamondin	Earthen	28	17.11 ± 1.11	0.32 ± 0.01
	Coconut husk	27	31.68 ± 1.61	0.47 ± 0.01
	Difference		14.57 ± 1.95	0.15 ± 0.01
	Earthen	28	17.11 ± 1.11	0.32 ± 0.01
	Bamboo	28	25.03 ± 1.61	0.44 ± 0.02
	Difference		7.92 ± 1.96	0.12 ± 0.02
	Coconut husk	27	31.68 ± 1.61	0.47 ± 0.01
	Bamboo	28	25.03 ± 1.61	0.44 ± 0.02
	Difference		6.65 ± 2.27	0.03 ± 0.02
Chico	Earthen	28	29.86 ± 1.16	0.54 ± 0.02
	Coconut husk	29	40.52 ± 1.05	0.61 ± 0.03
	Difference		10.66 ± 1.56	0.07 ± 0.03
	Earthen	28	29.86 ± 1.16	0.54 ± 0.02
	Bamboo	28	25.02 ± 1.54	0.47 ± 0.02
	Difference		4.84 ± 1.92	0.07 ± 0.03
	Coconut husk	29	40.52 ± 1.05	0.61 ± 0.03
	Bamboo	28	25.02 ± 1.54	0.47 ± 0.02
	Difference		15.50 ± 1.86	0.14 ± 0.03
Santol	Earthen	21	39.49 ± 1.42	0.74 ± 0.02
	Coconut husk	28	132.11 ± 1.52	1.44 ± 0.04
	Difference		92.62 ± 2.08	0.70 ± 0.04
	Earthen	21	39.49 ± 1.42	0.74 ± 0.02
	Bamboo	29	60.43 ± 1.72	0.90 ± 0.04
	Difference		20.94 ± 2.24	0.16 ± 0.04
	Coconut husk	28	132.11 ± 1.52	1.44 ± 0.04
	Bamboo	29	60.43 ± 1.72	0.90 ± 0.04
	Difference		71.68 ± 2.29	0.54 ± 0.05
Star apple	Earthen	30	65.96 ± 2.15	1.01 ± 0.03
	Coconut husk	30	109.10 ± 2.80	1.24 ± 0.04
	Difference		43.14 ± 3.52	0.23 ± 0.05
	Earthen	30	65.96 ± 2.15	1.01 ± 0.03
	Bamboo	29	60.98 ± 1.44	1.07 ± 0.02
	Difference		4.98 ± 2.58	0.06 ± 0.03
	Coconut husk	30	109.10 ± 2.80	1.24 ± 0.04
	Bamboo	29	60.98 ± 1.44	1.07 ± 0.02
	Difference		48.12 ± 3.14	0.17 ± 0.03

A COMPARATIVE STUDY OF CHICKS RAISED INDOORS AND OUTDOORS [1]

Modesto M. Ragat

Chicks are raised in the Philippines either indoors or outdoors. Both methods rely largely upon normal atmospheric conditions. It seems desirable to compare the effect of these methods of management on the chicks as to rate of growth, percentage of mortality, and economy of feed.

Lewis (1914) reported that the best growth among chicks can only be realized by giving them an abundance of free range. The overcrowding of range and housing space will cause much trouble during the developing period. Limited range, however, may be possible for rearing birds satisfactorily, but such requires more time and expensive methods of feeding. An abundance of free range promotes vigor and reduces the cost of feeding.

Kinghorne (1921) stated that abundance of free range with plenty of shade is necessary if chicks are to grow rapidly and develop into vigorous fowls. Growing chicks that have free range obtain quantities of green feeds, bugs, worms, and other things; therefore, they require less grain. Also, they are less liable to sickness and diseases.

Kennard (1928) and Alp (1931) agree on the advantages of what is called partial confinement of chicks. In this system, the chicks are brooded in confinement until they no longer need artificial heat. They are then moved into easily movable, inexpensive shelters on a range that is free from disease and parasitic contamination.

This experiment was conducted with the following objects: (*a*) to compare the rate of growth of chicks raised indoors with those raised on the range, (*b*) to determine the percentages of mortality of the growing birds, and (*c*) to determine which of the two methods of brooding chicks, indoors or on the range, is more profitable.

The experiment was started in November, 1936, and closed in December, 1937, covering a period of thirteen months. It was conducted in the Poultry Division of the Department of Animal Husbandry.

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[1] Experiment Station contribution No. 1331. Prepared in the Department of Animal Husbandry under the direction of Associate Professor F. M. Fronda.

PLAN OF THE STUDY

Chicks used. Los Baños Cantonese chicks artificially hatched in a 300-egg "Dapecol" hot water incubator were used. Three sets of observations of two lots each, which were designated as lot I, or outdoor, and lot II, or indoor, were made. The first set was run from November, 1936, to February, 1937, with 138 chicks; the second, from March to June, 1937, with 160 chicks; and the third, from September to December, 1937, with 140 chicks, making a total of 438 chicks for the three sets, and 219 in each lot.

Feeding. Both lots were fed with the same kind of ration consisting of the following ingredients, all parts by weight:

Rice bran	56 parts
Corn meal	19 parts
Shrimp meal	25 parts

One per cent of common table salt was added to this mixture.

The average prices per kilogram of the feeds used were based on the current prices in the local market and were as follows:

Corn meal	₱0.0446
Rice bran	0.0395
Salt	0.0115
Shrimp meal	0.1205

Based on these prices, 100 kilograms of the ration cost ₱6.09, including the common table salt.

The feeds were given in the form of dry mash in wooden feeding troughs, which were kept open to the birds during the day. Fresh cool water in bamboo watering troughs was always available to all the chicks.

Brooding. The chicks in both lots were raised in fireless brooders. In lot I (outdoor), they were immediately moved to the range and were brooded in a portable brooding house. They were confined in this house only during the first four days to adapt themselves gradually to the environment. From the fifth day up to the end of the twelfth week, the chicks were allowed freedom on a wide grassy range that was provided with abundant shade. On clear days, they were out roaming around from morning to roosting time in the evening. Even during rainy days, a number of the chicks were on the range.

The chicks in lot II (indoor), on the other hand, were brooded in the indoor brooding quarters provided with rice hulls as litter.

Each brooding quarter, however, was provided with an adjoining enclosed yard having an area of about ten square meters. Although the chicks in this lot had free access to this yard, most of the time they were observed to be inside the brooding quarters.

Records. The chicks were leg-banded, and weighed soon after they had been removed from the incubator and every seventh day thereafter up to the end of the twelfth week. A record of the amount of the feed consumed by each lot and of the mortality in each lot was kept.

RESULTS AND DISCUSSION

Rate of growth. Table 1 gives the mean weights at intervals of one week of the two lots of chicks observed. By reference to this table, it may be seen that although there was a difference of 0.4 ± 0.161 grams in the average initial weights of the chicks, this difference was not significant. By the end of the first week, the chicks in the outdoor lot, however, had grown heavier than those in the indoor lot; the difference in mean weight in favor of lot I (outdoor) was 1.2 ± 0.330 grams, which is significant. The significant difference in weight in favor of the outdoor lot was consistent to the close of the observation when the chicks were twelve weeks old. At the close of the experiment, the outdoor group, lot I, had an average weight of 572.2 ± 6.393 grams and the indoor group, lot II, 505.6 ± 6.699 grams, with a significant difference of 66.6 ± 9.27 grams in favor of the outdoor lot.

Inasmuch as the chicks in lots I and II were given the same ration, the difference in weights observed must be attributed to other factors. The chicks in lot I (outdoor lot) had free access to a wide grassy range. On the range they were able to get plenty of exercise under sunshine and to obtain extra feed in the form of insects and green grass. On the other hand, the only advantage which the chicks kept indoors might have had over those that were outdoors was the reduction of the chances for parasitic infestation. Between feed and parasite, the advantage is very much in favor of feed as shown by the experiment of Boncato (1932) with sheep and goats.

Mortality and vigor. Table 2 shows the mortality of the chicks in the first, second, and third sets. It may be observed that the mortality was highest in the second set in both lots. Although the third set was conducted during a stormy period, the mortality in lot I (outdoor) was very low, being only 11.43 per cent, the lowest in all the three sets, while that of lot II (indoor) was high, 41.43 per cent. Cloudy days prevailed when sets 1 and 3 were conducted, whereas set 2 was conducted during mostly clear sunny days. Most of the deaths in the outdoor lot occurred during the first eight weeks of the experiment, whereas in lot II (indoor), the deaths were evenly distributed during the first ten weeks. Although the average mortality for all the three sets was not significantly different in both lots, being only 14.10 ± 9.959, the mortality of lot I was consistently lower than that of lot II in all of three sets observed.

Feed consumption. The amount of feed consumed by each lot in the three sets is given in table 3. By reference to this table, it may be seen that the average feed consumption of each bird during the whole brooding period of 12 weeks was slightly lower in the outdoor lot than in that of the indoor. The feed consumption reported in the present study does not differ markedly from the figures previously reported in this College (Fronda, Badelles, and Padilla, 1934; Fronda and Kabigting, 1935; Dalid, 1936; Savella, 1936; Fronda and Agcanas, 1938; and Luna, 1939).

Returns above feed cost. The returns above feed cost, given in table 4, were determined on the basis of 100 chicks at the start. The average weights of the birds in each lot (table 1) at the close of the experiment were used as the basis in determining the total weights of the weanlings that might be produced from the 100 chicks. At ₱0.60 [2] a kilogram live weight, the total value of the weanlings that may be produced from 100 chicks was ₱26.68 for the outdoor lot and ₱19.58 for the indoor. Likewise, the total feed consumed by the same weanlings was determined from the average consumption by each lot (table 3). The total cost of the feed consumed by the weanlings at ₱6.09 per 100 kgm. was ₱10.78 for lot I (outdoor) and ₱9.43 for lot II (indoor). If the cost of feeds is deducted from the total value of the weanlings, the difference, representing the returns above feed cost, was higher in lot I (outdoor) than that in lot II (indoor). These figures show, therefore, that the outdoor lot was slightly more profitable than the indoor.

SUMMARY AND CONCLUSIONS

1. Although at the beginning of the experiment, no significant difference in weight of the chicks in the outdoor and indoor lots was apparent, the advantage in weight in favor of the outdoor lot began

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[2] The current price of table fowls sold in the Poultry Division of the Animal Husbandry Department, College of Agriculture, Los Baños, Laguna.

to show after one week and was consistent to the end of the brooding period of twelve weeks. At the end of twelve weeks, the average weights of the chicks were 572.2 ± 6.393 grams for the outdoor lot and 505.6 ± 6.699 grams for the indoor.

2. The average feed consumption per chick during the whole brooding period of twelve weeks was observed to be a little less in the outdoor lot, 2.27 ± 0.065 kgm., than in the indoor lot, 2.42 ± 0.116 kgm.

3. Lot II (indoor) had an average mortality of 36.12 ± 7.592 per cent, which was a little higher than that of lot I (outdoor), 22.02 ± 6.446 per cent.

4. The calculated returns above the cost of feed was higher, ₱15.90, in lot I (outdoor) than in lot II, (indoor) ₱10.15.

5. On the whole, of the two systems of rearing chicks studied, outdoor brooding produced better results than indoor brooding as to rate of growth, percentage of mortality, and economy of feed.

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TABLE 1

Weekly mean weights of the two lots of chicks studied

AGES	LOT I (OUTDOOR)		LOT II (INDOOR)	
	Number of chicks	Mean weights	Number of chicks	Mean weights
		grams		*grams*
At hatching time	219	26.5 ± 0.115	219	26.9 ± 0.113
1 week	212	33.8 ± 0.245	209	32.6 ± 0.221
2 weeks	207	46.0 ± 0.384	198	41.8 ± 0.405
3 weeks	201	65.6 ± 0.677	189	50.3 ± 0.617
4 weeks	196	88.6 ± 0.930	184	80.9 ± 0.928
5 weeks	189	128.5 ± 1.542	172	108.3 ± 1.411
6 weeks	184	168.8 ± 2.228	168	147.2 ± 2.118
7 weeks	179	218.4 ± 2.655	162	189.9 ± 2.255
8 weeks	173	294.8 ± 3.949	153	247.7 ± 3.836
9 weeks	170	370.2 ± 4.702	147	319.0 ± 4.534
10 weeks	170	441.5 ± 5.315	141	386.7 ± 4.791
11 weeks	170	498.7 ± 5.333	139	442.4 ± 5.666
12 weeks	170	572.2 ± 6.393	139	505.6 ± 6.699

TABLE 2

Mortality in the two lots up to 12 weeks old

SET	LOT I (OUTDOOR)			LOT II (INDOOR)		
	Number of chicks at hatching time	Number of chicks that died	Percentage of mortality	Number of chicks at hatching time	Number of chicks that died	Percentage of mortality
			per cent			*per cent*
1st	69	17	24.44	69	16	23.19
2nd	80	24	30.00	80	35	43.75
3rd	70	8	11.43	70	29	41.43
Average	--	—	22.02 ± 6.446	--	—	36.12 ± 7.592

TABLE 3

Average feed consumption of each lot up to 12 weeks old

SET	LOT I (OUTDOOR)	LOT II (INDOOR)
	kgm.	*kgm.*
1	2.31	2.23
2	2.34	2.56
3	2.16	2.48
Average	2.27 ± 0.065	2.42 ± 0.116

TABLE 4

Data on feed cost and returns above feed cost based on 100 chicks at the start

ITEMS	LOT I (OUTDOOR)	LOT II (INDOOR)
Number of chicks at the start	100	100
Number of chicks at the end of 12 weeks	78	64
Average amount of feed consumed per bird (in kgm.)	2.27	2.42
Total feed consumed by the lot (in kgm.)	177.06	154.88
Average weight of each weanling at the end of 12 weeks (in kgm.)	0.57	0.51
Total weight of weanlings in the lot (in kgm.)	44.46	32.64
Total value of weanlings in the lot @ ₱0.60 per kgm. (in pesos)	26.68	19.58
Total cost of feed consumed by the lot (in pesos)	10.78	9.43
Returns above feed cost (in pesos)	15.90	10.15

A REVIEW: GROWING PLANTS WITHOUT SOIL [1], [2]

This little book contains 65 pages included in twenty-two equally short chapters, an appendix consisting of twenty-five miscellaneous topics in fifty-seven pages, a glossary of scientific terms, and an index—138 pages in all. The booklet is therefore, very much padded with instructive and interesting but unrelated short chapters on Plant Growth Hormones, Budding and Grafting, etc. It was written in "response to the demand of those who are seeking the scientific facts, unbiased information, and the latest developments in this new science...". As the author said, the booklet "is of value to three classes of people, namely, (1) beginners and students, (2) those desiring a new hobby or new sphere of avocation, and (3) those who are engaged or intend to start in commercial fields of plant chemiculture."

The booklet as a whole is worth reading for it brings up to date the scattered information on Plant Chemiculture, the raising of plants in aqueous nutrient solutions, and as the author correctly claims, it gives "practical and up to date information for students, horticulturists, and hobbyists." The author candidly admits the limitation of the new science of Plant Chemiculture when he writes, "We don't expect to supplant the farm, but the greenhouse methods may be revolutionized."

In addition to the many tables at the end of the booklet which are included not for the beginner but for the advanced student and chemiculturist, there are interesting but brief accounts on the history, advantages, and functions of plant chemiculture, or soilless gardening. The author dwells on the relation of chemicals to plant and animal life, and on germination, aëration, acidity, and alkalinity of the solution culture media. He presents formulas for nutrient solutions and describes their preparation and use. He also describes construction of tanks, preparation of sand culture, and the construction and operation of greenhouses. He has compiled the characteristic symptoms of plants that are suffering from certain nutrient deficiencies, and from excess of these nutrients in plants.

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[1] MATLIN, D. R. 1939. Growing plants without soil. The A. B. C. of Plant Chemiculture (soilless agriculture, chemiculture, water culture, hydroponics, tank farming, sand culture) including plant growth hormones and their use. 138 p. New York. N. Y.: Chemical Publishing Co., Inc.

[2] General contribution from the College of Agriculture No. 689.

There are a few errors in spelling of names, in crediting a culture solution to a wrong party, and in incomplete or erroneous statements of facts. I think the correct names are Van Helmont and von Sachs. The 3-salt solution on page 18 was first used by Shive, not Tottingham. In his effort to show the advantages of chemiculture over the soil culture, the author contends that "Tomato plants can be planted for large scale production about one plant per square foot, while in soil they are usually planted 8 feet apart. Potatoes can be planted five times denser than in soil." This contention is neither borne out by facts nor in conformity with certain principles in plant physiology, except when the author admits that the plants grown in solution culture are far less developed than the similar ones grown directly in the soil. For the distance of planting is conditioned mainly by the spread of the crown.

The claim that "Chemiculture offers one way of evading the vagaries of the elements of nature, so that our food supplies will not be interfered with" is a rather sweeping statement, as the control is made possible only with the use of a greenhouse. But the plants that are grown in boxes, pots, and in field plots can also be saved if similarly protected. A number of such sweeping statements may be found in the book.

Speaking of Germany's potash and other deposits of plant nutrients, the author claims that it may be possible for that country "to utilize chemiculture to enable her to be self sufficient insofar as . . . grains are concerned." The concensus of opinion of those who know the advantages and the disadvantages of tank cultures, however, is that grains cannot conveniently or profitably be raised in tank cultures. The statement that "sodium, chlorine, and iodine are required for animal nutrition, but not for plants" does not hold true any more. For in plant nutrition, chlorine serves as a stimulant, iodine as a kriptotropic or secondary essential element, and sodium as a supplement to potassium.

Several other inadequate statements are found in the booklet. For instance, the author advises one to guard against high temperature in greenhouses, especially at night. According to him "if the plants get too hot, the respiration of the leaves is abnormally excessive so that the carbohydrates are oxidized and lost."

Of course, there is truth in this statement, but the author overlooks the fact that another harmful effect is excessive loss of water—transpiration.

Contradicting statements are also found in the booklet. The author recommends not only to use clean, white sand, not too fine, but even to treat the sand first with dilute sulfuric acid and then thoroughly wash it with water. At the same time in another part of the booklet may be found his advise that "One doesn't need to be so particular with the formulas used since the range of tolerance is greater" in sand culture. The reason for this advice appears rather antiquated, as it is based on the old and obsolete idea about "selective" absorption, and at the stme time overlooks "differential diffusion." which, at least in part, accounts for the intake of ions and molecules by the roots of plants. In his own words, "The reason for this is that while in water culture the plants must absorb all the elements present, in sand culture they have a certain power of selection."

Despite these few sweeping and at times contradicting statements, the booklet is full of valuable information on plant chemiculture and on matters more or less related to it as well. It should, therefore, be of practical value to those for whom the booklet has been written. The author does well in enumerating the advantages of plant chemiculture, some of which are the following:

1. It may be of value in "improving the quality of food products, of mineralizing the foods, of adding to the color and perfume of flowers, and of perfecting new products such as seedless tomatoes and seedless watermelons."

2. Hard manual labor is lessened, plow and hoes abolished, no cultivation or tillage of soil is necessary, and harvesting of the crop is simpler and less expensive.

3. "Food can be grown nearly anywhere and all year around."

4. "No rotation of crops is necessary. In soil the same crop cannot be grown year after year unless the soil is treated."

5. "Diseases and pests can be better controlled, especially those coming from the soil."

6. "Out of season crops can be grown commercially in hot houses so as to bring high prices."

7. It utilizes sand waste and barren areas.

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COLLEGE AND ALUMNI NOTES

Doctor David G. Fairchild of the Fairchild Garden in Florida, who is on a botanical expedition to the Far East, has been a guest on the School of Forestry campus during the last part of October. He is in the Philippines collecting seeds of new plants to be introduced in the Fairchild Arboretum. While staying on the Forestry Campus, Doctor Fairchild visited several departments of the College.

Doctor F. O. Santos, head of the Department of Agricultural Chemistry, and Dr. G. O. Ocfemia, head of the department of Plant Pathology, returned to the College campus on October 22 after attending as delegates of the Commonwealth Government, the Sixth Pacific Science Congress, which was held in Berkeley and Treasure Island from July 24 to August 5, and at Stanford University at Palo Alto from August 6 to 12. After the Congress, Doctors Santos and Ocfemia visited, on their way East, many educational institutions and laboratories. Among these were California Institute of Technology, University of Southern California, Iowa State College, U. S. Regional By-Products Laboratory at Ames, University of Wisconsin, U. S. Forest Products Laboratory at Madison, University of Illinois, U. S. Soybean Industrial Products Laboratory at Urbana, University of Chicago, University of Michigan, Mellon Institute, University of Pittsburgh, U. S. Department of Agriculture, Columbia University, Yale University, and Harvard University.

Doctor Ocfemia, while at New York, attended the Third International Congress for Microbiology from Sept. 2 to 9, and, at Princeton, visited the Rockefeller Institute for Medical Research. Doctor Santos took occasion to visit the Squibb Institute for Medical Research at New Brunswick; and at Tokyo, he visited the Imperial Government Institute for Nutrition.

Another campus arrival is Prof. H. L. Richards, acting head of the Department of English, who went on detail last March to take some courses in the University of California. Prof. Richards was in London visiting her family at the outbreak of the European war. Instead of returning to the Philippines via Suez, Prof. Richards was forced to return to the United States and come via the Pacific.

Dr. W. A. Muller, of the Department of Public Instruction and Culture, Java, visited the College on November 2, where he inspected some of the laboratories and classes. Dr. Muller has been spending a few weeks in the Philippines in connection with a commission from the Dutch East Indies government to study and prepare a book on the educational system of the Oriental countries.

A STUDY OF THE GROWTH HABIT OF RICE PLANTS: IV. LOCALITY AND GRAINS[1]

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WITH ONE CHART

Great interest has been centered upon the size of rice grains (Lord and Abeyesundra, 1929; Ramiah and Parthasarathi, 1933; Juliano, 1938, 1939; Apaoan, 1939), not only because this has been found to be the most stable of all characters of the rice plant, but also because of the important rôle that size has played in the systematics of the cultivated rices (Gustchin, 1934; Piacco, 1936, 1938). Although this character is not at all indifferent and immune to the effects of environment (Tin, 1936; Juliano, 1938, 1939; Apaoan, 1939), it has been demonstrated beyond doubt that it is an important and convenient criterion in classifying cultivated rices and it is surmised that it will be an interesting factor in the commercial classification of our cultivated rices in the future.

This paper represents the fourth series of studies on the growth habit of a pure line of Guinangang rice plants. It deals with the tillering habit, mean heights, mean number of bearing culms per hill, and measurements of the length, breadth, and thickness of the hulled grains of plants grown in the College of Agriculture in 1937, and their progenies in four different provinces of the Philippines during 1938. The chemical composition of the unhulled and hulled grains of those plants was also determined.

MATERIALS AND METHODS

On March 22, 1938, requests to grow a pure line Guinangang rice variety from the harvest grown by Juliano (1938)[2] in the field plots were sent to thirteen Agricultural High Schools under the Bureau of Education. Fortunately enough, six of these accepted the

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[1] Experiment Station contribution No. 1332. Read before the Los Baños Biological Club on October 26, 1939. This investigation was made possible by research grants-in-aid from the President of the University of the Philippines and the National Research Council of the Philippines.

[2] Data were obtained from plants grown in small paddies near the Department of Agricultural Botany, Agricultural College, Laguna.

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invitation, but only four of them were able to grow the plants to maturity and perform the outline of work submitted to them by the writer. These were Batac Rural High School, Batac, Ilocos Norte; Lagañgilang Agricultural High School, Lagañgilang, Abra; Bañga Rural High School, Bañga, Capiz; and Upi Agricultural High School, Upi, Cotabato.[3]

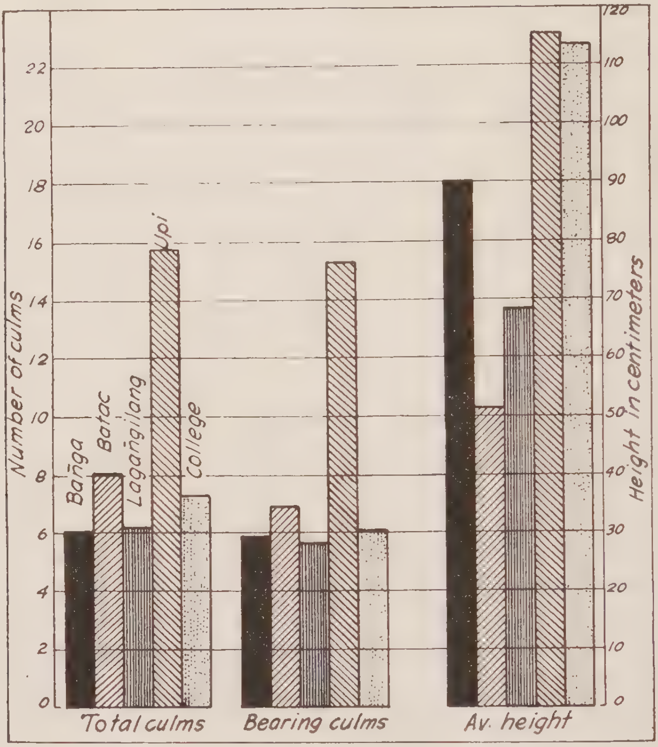

Chart 1.—Behavior of plants.

The seeds harvested from the second field planting of Juliano (1938) were sent to these high schools by mail. As soon as the seeds were received, these were cleaned as usual and planted in seed beds. Fortunately, the seed beds employed by these high schools in germinating the seeds were nearly identical (table 2). The seedlings were transplanted one seedling to a hill at variable distances. The number of hills planted by each school was rather variable also, owing perhaps to differences in the relative germination percentages of the seeds planted. Upi High School, for example, was able to plant the most hills (2,043), while Lagañgilang had only 364 hills.

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[3] The writer is indebted to Mr. Julian Mamaril of Batac Rural High School, Messrs. José A. Reyna and Victoriano C. Lopez of Lagañgilang Agricultural High School, Messrs. Basilio O. Viado and Numeriano L. Cuevas of Bañga Rural High School, and Mr. José A. Serrano of the Upi Agricultural High School, all of whom were instrumental in growing the plants from seedlings to maturity and collecting the data presented in this paper.

During the growth of the plants in the field, several observations were made: namely, the dates of booting of the first and last hill in the cultures, the dates of emergence of the inflorescence from the first and last hill, and the time the seeds were harvested. Some time before the seeds or panicles were harvested, one hundred hills were selected at random and the number of bearing and nonbearing culms per hill were counted. The heights in centimeters of the shortest and tallest culm in each hill were measured following the procedure adopted by Juliano (1938). None of the cultures except that one grown in the College of Agriculture in 1937, received artificial irrigation water but they had to depend on the rain for their water supply.

Panicles from all the hills were then gathered, their grains threshed by hand, and a chupa of the harvested grains was mailed to the writer by each of those high schools. The length, breadth, and thickness[4] of one thousand hulled grains selected at random from the samples received by the writer were measured with a microcaliper in the Department of Agricultural Botany. The chemical analyses of the unhulled and hulled grains were done by the Department of Agricultural Chemistry of the College of Agriculture.

RESULTS AND DISCUSSION

Rainfall

The four provinces where the plants used in this study were grown are rather far from each other. Upi, Cotabato, where there is no decided dry season, possesses the fourth type of climate (Anonymous, 1939). Bañga, Capiz; Batac, Ilocos Sur; and Lagañgilang, Abra, where distinct dry and wet months prevail, belong to the first type. The College of Agriculture may perhaps belong to the intermediate type where the dry months or periods are relatively short. The lowest amount of monthly rainfall was registered in Lagañgilang, Abra (table 1).

According to a personal letter by the Director of the Weather Bureau, the weather stations at Batac, Ilocos Norte, and Lagañgilang, were opened last May and July, 1938, respectively. In Bañga, Capiz, there is no weather station; but the nearest one to this town is that of Mambucao, which was opened only last May, 1938. It was not possible then to present complete monthly rainfall records for all these places for 1938. The monthly rainfall for the months of September to December, 1938, were kindly supplied by the Director of the Weather Bureau, while the rest of the monthly rainfall readings (table 1) were obtained from the Weather Bureau Meteorological Bulletin from January to August, 1938.

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[4] Mr. Lorenzo S. Barredo, who was paid from the grant-in-aid from the National Research Council of the Philippines, was the one who measured all the hulled grains used in this study.

Seed bed

The seed beds used in growing the seeds in the different schools happened to be nearly identical (table 2). In Lagañgilang, Abra, for example, the seeds were grown in a rich soil, fenced around to protect the seedlings from stray animals. The ground was plowed and harrowed three times. Then a piece of land one meter by two meters was selected and dug up with a spading fork. The bed was cleared of all roots and rubbish, and was raised about four inches to form a ridge. With the use of a dibble, holes were dug 3 to 5 centimeters deep and 10 centimeters apart each way. About 15 to 20 seeds were dropped in each hole. The bed was a dry one as no irrigation water was used, and the seedlings had to depend entirely upon the rain for their growth and development.

The seed bed used in Batac, Ilocos Sur, was one of the vacant hog lots utilized as a seed bed the previous year. The ground was also plowed and harrowed four times so as to insure the elimination of the weeds. The portion selected was again dug with a spading fork and the seeds were then hand-drilled in holes 10 centimeters apart, 5 to 6 seeds to the hill. This seed bed also was not irrigated artificially as it depended solely on the rain.

In Bañga, Capiz, where a dry seed bed also was employed, the seeds were broadcasted on a previously well prepared ground. In Upi, Cotabato, an ordinary well-cultivated garden plot was utilized as a seed bed, and the seeds were drilled. Even if the methods of planting the seeds were not exactly the same in these four places, the principle involved was nearly identical in that the seeds were grown on non-irrigated dry land and depended on rainfall for water supply. In the College of Agriculture, the seeds were sown in a well-prepared, puddled, and irrigated paddy so that the seedlings were able to be transplanted much earlier.

The time of planting the seeds in the seed bed was affected by the amount of rainfall then obtaining in the different places (table 2). In Bañga, Capiz, for example, the seeds were planted on June 16, 1938; in Batac, Ilocos Norte, on June 7, 1938; in Lagañgilang, Abra, on June 10, 1938; and at Upi, Cotabato, on May 5, 1938.

Age of seedlings

The age of the seedlings when transplanted also varied in the different localities (table 2). The variation in age of the seedlings at transplanting time ranged from 21 days in the College of Agriculture to 52 days in Batac, Ilocos Norte. The seedlings were 28 days old when they were transplanted in Bañga, Capiz, 30 days old when transplanted in Lagañgilang, Abra, and 41 days old when transplanted in Upi, Cotabato. Whether these ages of the seedlings were the ones ordinarily adhered to in those localities in transplanting seedlings of other varieties of rice, or whether the vigor or height of the seedlings had something to do with the time of transplanting is not known to the writer.

Distance between hills

In being transplanted only one seedling was placed to each hill in all cases. The distance between the hills varied widely in the different places. The distance employed ranged from 14.5 × 14.5 centimeters in the College of Agriculture, Laguna, to 30 × 30 centimeters in Lagañgilang, Abra. Those planted in Bañga, Capiz, were placed 16 × 18 centimeters apart; those from Upi, Cotabato, 20 × 20 centimeters; and those from Batac, Ilocos Norte, 25 × 25 centimeters apart (table 2).

Inasmuch as the percentage of germination of the seeds was not perhaps identical in the different samples sent to those high schools, the number of hills planted by them was also variable. The largest number of hills grown was in Upi, Cotabato (2,043 hills), while the least was found in Lagañgilang, Abra (364 hills).

Booting

The time of booting of the first hills of the cultures under observation by those schools was not at all affected by the distance between the seedlings, nor by the age of the seedlings at transplanting time. Booting was first observed in Lagañgilang, Abra, on August 10, 1938, and in Upi, Cotabato, on August 20, 1938, the former booting 10 days earlier than the latter. Those grown in Bañga, Capiz, and Batac, Ilocos Norte, booted on September 15 and 19, 1938, respectively. The time required for all the hills to boot was of course dependent on the number of hills planted, but this condition does not seem to hold true with those plants grown in Bañga, Capiz, and Batac, Ilocos Norte. In the former where less hills (652) were planted, the plants required 25 days for all to boot, whereas in the latter where 763 hills were grown, the plants required only 21 days to boot.

As to the age of the plants when the first hill booted, great variation was also exhibited. The number of days from transplanting to the booting of the first hill was as follows: Lagañgilang, 31 days; Batac, 25 days; College of Agriculture, 61 days; Bañga, 63 days; and Upi, 64 days. It seems that the time of booting is not at all dependent on the age of the seedlings at transplanting time nor on the distance employed between the hills.

The time interval between the booting and emergence of the panicles from the first hill ranged from 4 days (Bañga and Batac) to 26 days (Lagañgilang). In the College of Agriculture, Laguna, and in Upi, Cotabato, this time interval was 8 days and 6 days, respectively. The longer time required by the panicles to emerge from plants grown in Lagañgilang, Abra, was due perhaps to factors which are unknown to the writer, although the amount of rainfall then available in that locality when the plants were then at their booting stage was rather high (table 1). In general however, the inflorescence required nearly a week to emerge after booting, as was observed by Ramiah and Narashimhan (1936) in India. Sethi, *et al* (1936) found that flowering duration was affected by age of the seedling, even in pure line, although the mean flowering duration varied slightly with the date of transplanting.

Harvest time

It is very interesting to note that the time of harvest took place in October, 1938, no matter how late or how early the seeds were grown in the seed beds, or how old the seedlings were when they were transplanted in the fields (table 2). Plants from Upi, Cotabato, were harvested when they were 166 days old (October 19, 1938), while those from Lagañgilang, Abra, were only 124 days old (October 12, 1938). In Bañga, Capiz, the plants were 127 days old when their panicles were gathered, while those from Batac, Ilocos Norte, were 141 days old. In the College of Agriculture, harvesting of the panicles took place when the plants were 125 days old. In the locality where the original seeds were gathered in 1936 and where abundance of irrigation water is available any time, this variety usually matures from 113 to 130 days from the time of planting in the seed bed. From the data herein presented, it seems that there is a tendency for the growth period of this variety to increase where the amount of rainfall is more (table 1). It is probable that the growth period of this variety and perhaps other rice varieties as well is not at all fixed, as this is influenced by the environment. It would not be safe, therefore, to say that, if a variety matures, for instance within 120 days in one locality, this same variety when grown in another place can be expected to mature within the same period of time. Duration as a varietal character is perhaps useless for classification of rice varieties.

Number of tillers

The plants used in this study were obtained from progenies of a pure line rice, and as such they should be considered coming from a rather homogeneous population. Whatever differences, therefore, may be exhibited by these plants when grown in different localities must of necessity be interpreted as resulting from the effects of their environment. In studies of a number of our local rice varieties, Rodrigo (1924) and Calvo (1927) have found, among other things, that the tillering capacity of rice is governed by various factors, such as spacing, number of seedlings to the hill, varietal characters, and certain environmental conditions. Inasmuch as the distance between the hills was variable, the tillering capacity of the individual plants must also be variable (table 3, chart 1). The optimum distance between the seedlings for this particular variety is not known, but the data presented in tables 2 and 3 show clearly that plants grown in Upi, Cotabato, and Batac, Ilocos Norte, gave the most tillers per hill. It is probable that the two factors, distance between the hills as well as the fertility of the land and amount of rainfall, brought about the differences in the mean number of tillers produced by each seedling.

The variation in the mean number of tillers per hill ranged from 15.94 ±0.41446 in Upi, Cotabato, to 6.07 ± 0.2517 in Bañga, Capiz (table 3). With the exception of the readings from Lagañgilang, Abra, and Bañga, Capiz, where no significant difference (0.12 ± 0.3189) was obtained, significant differences in the number of tillers produced by each plant to the hill were manifested among the other plants.

When the four groups of plants were compared as to the variance of the different populations and then their respective means, the following data were obtained:

SOURCE OF VARIATION	ESTIMATE OF POPULATION VARIANCE	DEGREES OF FREEDOM	SUM OF SQUARES
Items within groups	20.6600	495	10227.9200
Group means	92.5948	4	227.7844
Total		499	10455.7044

$$F = \frac{92.5948}{20.6600} = 4.48 \text{ surpasses the 1 per cent, 3.3584, for 4 and 395 } df.$$

The estimate of variance based on the group population is very much less than that from the group means, the ratio being more than 4 times the other. With the use of Fischer's (1936) test for one estimate of variance derived from n_1 degrees of freedom with that such estimate derived from n_2 degrees of freedom, as recommended by Snedecor (1938), it was found that the 1 per cent, 3.3584, is exceeded by the sample value (4.48). This clearly indicates that either the number of tiller variation was not drawn from a single population but from different ones characterizing the different groups of plants, or that their means differ significantly among themselves owing to variable environmental conditions in the different localities. The former seems improbable as the seeds sown by all those schools belong to the same population.

The mean number of tillers produced by each plant must necessarily determine the mean number of bearing culms; that is, the more tillers there are to a plant, the more bearing culms are expected to result from them. Plants from Upi, Cotabato, gave practically 97.43 per cent of the mean number of tillers producing panicles, while those from the College of Agriculture gave only 83.31 per cent. In the other localities the percentages of bearing culms were 86.17 for Batac, 92.25 for Lagañgilang, and 96.86 for Bañga. The foregoing results imply definitely that tillering capacity of a variety is greatly influenced by environment as has been also concluded by Rodrigo (1924), Calvo (1927), and other workers, and as such it can not be considered a good varietal character for systematic work.

Average mean height

Height as a character of the rice plant is as variable as the characters discussed above (fig. 1). Results shown in table 3 clearly indicate how much this character was influenced by locality. Even in provinces which are very close to each other, the difference in the average mean height of the plants was significant. It is probable that much more interesting results could have been obtained if more provinces had been able to grow the rice used in this study.

Size of hulled grains

Of all characters of the rice plant, the size of the grain seems to have been generally recognized as the most stable (Kikkawa, 1912; Graham, 1913; Beale, 1927; Sethi and Saxena, 1930; Ramiah, *et al*, 1933) and more constant than any other vegetative character. Within a pure line, grain size does not vary any appreciable extent (Ramiah and Parthasarathi, 1933). On the other hand, Tin (1936) reports that the grain lengths (unhulled grain) from different panicles of one plant differ significantly, and this holds true also of the means of panicles of different plants, so that variation within a plant and within a variety are definite even in stabilized agrotypes which have been grown in pure cultures for a number of years in the same place and under identical conditions. Apaoan (1939) finds that hulled grains from plants grown in cans in the sun are significantly longer, thicker, and broader than those in the shade, and that the former are significantly heavier (either hulled or unhulled) than the latter. Not much difference between the length, breadth, and thickness of hulled grains from the can and the field (Juliano, 1938) is evident, but typhoons have a detrimental effect upon the mean length, breadth, and thickness.

Juliano (1939) reports that in general hulled grains from the first crop are longer and broader than those from their ratoons, but the mean thickness seems to be rather adversely affected especially when grown in the field. Fertilization has a marked influence on the mean length and breadth of plants grown in tin cans whether they be from the first crop or their ratoons. Under field plot conditions this same author (Juliano, 1939) finds no marked difference in favor of fertilization, especially with the mean breadth, but the mean thickness is favorably affected. In other words, grain size, although considered the most stable of all characters of the rice plant, is greatly influenced by fertilization, shading, typhoons, and ratooning, but the variation so far reported is much less than that found in the vegetative characters (Juliano, 1938, 1939; Apaoan, 1938).

In the measurements of unhulled grains of several local and exotic rice varieties, Capinpin and Punyasingh (1939) found that length is the most dependable of the three grain dimensions. Juliano (1938) also found that mean length of hulled grains is the least variable. In this study, however, the mean breadth and mean thickness (table 4) showed less standard deviation than the mean length. These contradicting results seem to point to the possibility of a general conclusion that under certain definite conditions then existing in this study, the three dimensional characters are fairly dependable for use in the classification of rice varieties.

Mean length. Results of measurements of 7,598 hulled grains obtained from plants grown in five different places of the Philippines show that their mean length does not vary considerably (table 4). The longest mean length of hulled grains was obtained from those harvested in Lagañgilang, Abra, (6.1634 ± 0.0481 millimeters), while the shortest was from those obtained from Batac, Ilocos Norte (6.0063 ± 0.437 millimeters). It so happened that plants grown in Upi, Cotabato, were the tallest and the most vigorous, producing 15.94 ± 0.41446 mean number of culms per hill and a mean average height of 115.375 ± 0.15234 centimeters. As to mean length of hulled grains, plants from Upi only ranked the fourth. On the other hand, Batac plants which happened to give the least grain mean length were the shortest in average mean height (51.445 ± 0.16827 centimeters) and fourth in mean number of culms per hill (8.10 ± 0.21029). From the foregoing figures it is probably safe to state that average mean height of the plants has nothing to do with the size of the hulled grains.

When the mean lengths of the hulled grains obtained from the different groups of plants raised in the four provinces of the Philippines in 1938 and those grown by Juliano (1938) in 1937 are compared with each other (table 5), it is found that six out of ten differences are insignificant. This result is certainly in favor of the belief that grain length is not considerably affected by locality, time of sowing and transplanting, and distance of planting, provided that the variety of rice grown is pure. In other words, this dimensional attribute of hulled grains can be depended upon as a fairly constant and useful criterion in the classification of cultivated rices, a fact that has been recognized by other workers.

Mean width. In mean width of hulled grains there was less variability than in their mean length (table 4). The range of the mean width was from 2.4079 ± 0.0257 millimeters with plants grown in the College of Agriculture, Laguna, to 2.2629 ± 0.0369 millimeters from those grown in Batac, Ilocos Norte. As in their mean length, mean width does not seem to be correlated with the vigor of the plants, if mean average height is to be taken as a criterion for vigor, although the shortest plants (Batac) exhibited the least mean width.

The differences between the mean width of the hulled grains from the different groups of plants also indicate how much reliance we can give to this metrical attribute of the grains for use in the classification of cultivated rices. In seven out of ten, the differences were insignificant (table 5).

Mean thickness. The standard deviation in mean thickness of hulled grains is the least of the three dimensional attributes studied in this paper (table 4). The range of the mean thickness was from 1.6807 ± 0.0249 millimeters from plants grown in Batac, Ilocos Norte, which gave the shortest mean average height to 1.7436 ± 0.0293 millimeters from plants raised in Lagañgilang, Abra. The differences between the means (table 5) were all insignificant. This result, together with those cited above, conclusively strengthens the writer's belief that environment affects grain size the least.

Chemical analyses

The chemical analyses of hulled and unhulled grains (palay) harvested from plants grown in the four provinces mentioned above and from those raised in 1937 in the College of Agriculture, Laguna, are shown in table 6. Results of such analyses may indicate at least whether there is reason for people to show preference for rice obtained from one locality over the same kind harvested in other places; this condition is similar to the preference shown for lanzones from the town of Paete, Laguna. The same data may further show whether in buying rice one would have an equal chance of securing a product of nearly identical nutritive qualities, immaterial of their place of origin.

Unhulled grains or palay. The chemical composition of unhulled grains from the different groups of plants is rather variable (table

6). While one grain sample (Lagañgilang, Abra) excels the others in fats or is poor in carbohydrates (Bañga, Capiz), this same sample is low in crude fiber or high in protein content. In other words, the chemical composition of unhulled grains is not constant even in a pure variety as this is greatly affected by the environment under which the plants are grown, a condition that is also true with many of the vegetative characters of the rice plant studied in this paper and similarly found by Juliano (1938) and Apaoan (1939).

If mean height of plants is taken as an index of the degree of fertility of the soil in which the plants are grown (table 2; fig. 1), then unhulled grains harvested from plants raised in Upi, Cotabato, would be expected to have high ash and perhaps even protein content. Results herein presented showed that Upi grains were only third in ash and protein content, were poor in fats and crude fibers, but far excelled the others in carbohydrates. Unhulled grains from the College of Agriculture, however, gave the highest ash content (8.12 per cent) although they were only second in mean height and mean number of tillers per hill or plant.

Hulled grains. Inasmuch as the hull of the grains is not directly used for food, the chemical composition of hulled grains is perhaps a better measure for comparison. Results of chemical analyses of hulled grains (table 6) were as variable as those of the unhulled grains or palay. The most vigorous plants from Upi, Cotabato, yielded the highest ash content (1.70 per cent). Samples from Batac, Ilocos Norte, have the highest protein content (12.91 per cent) and crude fiber (1.41 per cent), while those from Lagañgilang, Abra, contained the greatest amount of fat (6.83 per cent), moisture content (14.49 per cent), and calorific value (367). It seems that some degree of correlation exists between soil fertility as expressed in mean average height of the plants and the ash content of the hulled grains.

SUMMARY AND CONCLUSIONS

The present study, which deals with the growth habit of Guinangang rice plants grown in five different provinces of the Philippines in 1937 and 1938, will be of value to many investigators interested in the utilization of grain size in the classification of cultivated rices. The results herein obtained may be summarized as follows:

1. The four localities where the plants of a pure line Guinangang rice variety were grown in 1938 were: Batac Rural High School, Batac, Ilocos Norte; Lagañgilang Agricultural High School, Lagañgilang,

Abra; Bañga Rural High School, Bañga, Capiz; and Upi Agricultural High School, Upi, Cotabato. The source of the seeds grown in the above mentioned places was the field plot plants raised in the College of Agriculture, Laguna, (Juliano, 1938) in 1937. These five places represent practically three distinct types of climate: namely, the first type (Batac, Lagañgilang, and Bañga) where there are distinct dry and wet months, the fourth type (Upi) where there is no decided dry season at all, and an intermediate type (College of Agriculture) where the dry period is relatively very short.

2. The time of booting, emergence of inflorescence, and flowering duration were different in the different groups of plants; but the time of harvest fell in the same month (October, 1938) in four of them, immaterial of the date of sowing in the seed beds, age of the seedlings at transplanting time, and the distance employed between the hills.

3. The mean number of tillers, mean number of bearing culms, and mean height of the plants to the hill were different in the different cultures.

4. Of the three dimensions of the hulled grains, mean thickness was the least variable; mean breadth ranked the second; and the mean length was the most variable of them all. These three metrical attributes of the hulled grains as far as the results herein presented are concerned, were not materially affected by environmental conditions then prevailing in the localities where the plants were grown.

5. Chemical analyses of either unhulled or hulled grains (palay) obtained from plants raised in the five localities mentioned above revealed that chemical composition of hulled or unhulled grains is not a safe character to use in the classification of rice varieties as this is highly influenced by environment even if the sample belongs to a pure line and to a homogeneous population. A relationship was indicated between soil fertility expressed in mean height of the plants and ash content of the hulled grains.

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TABLE 1

Total monthly rainfall in millimeters during the year 1938 [a]

LOCALITIES	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE
Mambusao, Capiz [b]	—	—	—	—	181.1	280.6
Batac, Ilocos Norte [b]	—	—	—	—	72.6	263.3
Lagañgilang, Abra [b]	—	—	—	—	—	—
Upi, Cotabato	117.0	47.0	84.0	194.8	373.6	263.0
Agricultural College, Laguna	52.0	35.6	54.6	27.3	184.3	115.3

[a] Readings from September to December, 1938, were kindly supplied by the Director of the Weather Bureau. The rest of the data were taken from the Weather Bureau Meteorological Bulletin from January to August, 1938.

TABLE 1 (continued)

LOCALITIES	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
Mambusao, Capiz [b]	306.8	300.6	260.0	273.4	337.1	310.1
Batac, Ilocos Norte [b]	284.7	324.9	145.1	104.9	23.6	50.6
Lagañgilang, Abra [b]	49.7	168.4	179.8	110.6	4.4	4.9
Upi, Cotabato	301.4	211.7	168.3	289.0	207.1	170.2
Agricultural College, Laguna	233.5	385.9	287.4	448.4	323.9	297.1

[b] Batac, Ilocos Norte; Mambusao, Capiz; and Lagañgilang, Abra; are new stations of the Weather Bureau. No weather station is maintained in Bañga, Capiz; Mambusao was given by the Director of the Weather Bureau as the nearest weather station to Bañga, Capiz.

TABLE 2

Summary of observations

LOCALITIES	DATE PLANTED IN SEED BED	METHOD OF PREPARING SEED BED	DATE OF TRANSPLANTING [b]	DISTANCE BETWEEN HILL	NUMBER OF HILLS PLANTED
				cm.	
Bañga, Capiz [c]	June 6, 1938	Dry seed bed	July 14, 1938 (28 days)	16 × 18	652
Batac, Ilocos Norte	June 7, 1938	Dry seed bed; drilled	July 29, 1938 (52 days)	25 × 25	763
Lagañgilang, Abra	June 10, 1938	Bakal	July 10, 1938 (30 days)	30 × 30	364
Upi, Cotabato [d]	May 6, 1938	Ordinary garden plot	June 17, 1938 (41 days)	20 × 20	2043
Agricultural College, Laguna	Aug. 8, 1937	Dapog	Aug. 29, 1937 (21 days)	14.5× 14.5	100

[b, c, d] See footnotes on page 622.

TABLE 2 (continued)

LOCALITIES	DATE WHEN FIRST HILL BOOTED [a]	DATE WHEN LAST HILL BOOTED [a]	DATE WHEN FIRST INFLORESCENCE EMERGED [a]	DATE WHEN LAST INFLORESCENCE EMERGED [a]	DATE WHEN HARVESTED [b]
Bañga, Capiz [c]	Sept. 15, 1938 (63 days)	Oct. 10, 1938 (88 days)	Sept. 19, 1938 (67 days)	Oct. 15, 1938 (93 days)	Oct. 21, 1938 (127 days)
Batac, Ilocos Norte	Sept. 19, 1938 (52 days)	Oct. 10, 1938 (73 days)	Sept. 23, 1938 (56 days)	(Oct. 15, 1938 (78 days)	Oct. 26, 1938 (141 days)
Lagañgilang, Abra	Aug. 10, 1938 (31 days)	Aug. 25, 1938 (46 days)	Sept. 5, 1938 (57 days)	Sept. 18, 1938 (70 days)	Oct. 12, 1938 (124 days)
Upi, Cotabato [d]	Aug. 20, 1938 (64 days)	Sept. 16, 1938 (91 days)	Aug. 26, 1938 (70 days)	Sept. 27, 1938 (102 days)	Oct. 19, 1938 (166 days)
Agricultural College, Laguna	Oct. 29, 1937 (61 days)		Nov. 6, 1937 (69 days)	Nov. 13, 1937 (76 days)	Dec. 9, 1937 (125 days)

[a] Days in parentheses computed from date of transplanting.

[b] Days in parentheses computed from date of seeding.

[c] Attacked by rice bugs and borers.

[d] Flood on July 11, 1938, and twenty hills were carried away; typhoon on October 5, 1938, and all the plants were standing before the typhoon occurred.

TABLE 3

Mean number of tillers and bearing culms, and average height in centimeters per hill

LOCALITIES	TOTAL TILLERS			BEARING CULMS			AVERAGE HEIGHT		
	Mean	Standard error	Standard deviation	Mean	Standard error	Standard deviation	Mean	Standard error	Standard deviation
Bañga	6.07	0.25170	2.5170	5.88	0.25670	2.5670	90.070	0.24967	2.4967
Batac	8.10	0.21029	2.1029	6.98	0.19150	1.9150	51.445	0.16827	1.6827
Lagañgilang	6.19	0.19576	1.9567	5.71	0.19555	1.9555	68.395	0.18980	1.8980
Upi	15.94	0.41446	4.1446	15.53	0.42006	4.2006	115.375	0.15234	1.5234
Agricultural College	7.37	0.24267	2.4267	6.14	0.27725	2.7725	113.880	0.21678	2.1678

TABLE 4

Mean length, width, and thickness of hulled grains in millimeters

LOCALITIES	LENGTH			BREADTH			THICKNESS		
	Mean	Standard error	Standard deviation	Mean	Standard error	Standard deviation	Mean	Standard error	Standard deviation
Agricultural College	6.1120	0.0226	1.354	2.4079	0.0257	1.529	1.6884	0.0222	1.3332
Lagañgilang	6.1634	0.0481	1.484	2.3415	0.0383	1.211	1.7436	0.0293	0.9230
Bañga	6.0245	0.0355	1.145	2.3221	0.0356	1.144	1.7011	0.0273	0.8636
Upi	6.0731	0.0462	1.460	2.3774	0.0369	1.167	1.7170	0.0298	0.9428
Batac	6.0063	0.0437	1.382	2.2629	0.0369	1.165	1.6807	0.0249	0.7904

TABLE 5

Differences in mean length, breadth, and thickness of hulled grains in millimeters

LOCALITIES	LENGTH		WIDTH		THICKNESS	
	Difference	Standard error	Difference	Standard error	Difference	Standard error
Lagañgilang—Agricultural College ...	0.0514	0.0523 [a]	—0.0654 [b]	0.0433 [a]	0.0552	0.0367 [a]
Lagañgilang—Upi	0.0903	0.0660 [a]	—0.0359	0.0560 [a]	0.0266	0.0417 [a]
Lagañgilang—Bañga	0.1389	0.0595	0.0194	0.0513 [a]	0.0425	0.0399 [a]
Lagañgilang—Batac	0.1571	0.0643	0.0786	0.0522 [a]	0.0629	0.0383 [a]
Agricultural College—Upi	0.0389	0.0514 [a]	0.0305	0.0500 [a]	—0.0286	0.0372 [a]
Agricultural College—Bañga	0.0875	0.0426	0.0858	0.0401	—0.0127	0.0352 [a]
Agricultural College—Batac	0.1057	0.0491	0.2080	0.0421	0.0077	0.0334 [a]
Upi—Bañga	0.0486	0.0581 [a]	0.0553	0.0494 [a]	0.0159	0.0404 [a]
Upi—Batac	0.0668	0.0636 [a]	0.1145	0.0503	0.0363	0.0389 [a]
Bañga—Batac	0.0182	0.0567 [a]	0.0592	0.0513 [a]	0.0204	0.0370 [a]

[a] Insignificant.

[b] Minus sign before the figure indicates the first of the items compared had smaller reading than the second.

TABLE 6

Chemical analyses of unhulled and hulled grains

ITEMS	BAÑGA, CAPIZ		BATAC, ILOCOS NORTE		LAGAÑGILANG, ABRA		UPI, COTABATO		AGRICULTURAL COLLEGE LAGUNA	
	Unhulled	Hulled	Unhulled	Hulled	Unhulled	Hulled	Unhulled	Hulled	Unhulled	Hulled
	per cent	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*
Moisture	12.49	14.34	12.13	13.92	12.51	14.49	13.05	13.75	12.75	13.24
Fats (ether extract) ..	1.12	1.34	1.18	2.94	1.35	6.83	1.04	0.88	1.06	1.40
Ash	7.95	1.63	6.55	1.42	5.83	1.45	6.56	1.70	8.12	1.51
Protein (N × 6.25) ...	9.01	10.13	8.91	12.91	6.91	6.75	7.50	8.44	6.16	7.85
Crude fiber	10.29	0.95	9.73	1.41	11.87	0.91	9.39	1.40	10.94	0.70
Carbohydrate (N.F.E.)[a].	59.14	71.61	61.50	67.40	61.53	69.57	62.46	73.83	60.97	75.30
Calories per 100 grams[a]	283.00	339.00	292.00	348.00	286.00	367.00	289.00	337.00	285.00	354.00

[a] Computed.

BIOLOGY OF KALOULA PICTA (DUMÉRIL ET BIBRON) WITH SPECIAL REFERENCE TO ITS DEVELOPMENT AND BREEDING HABITS[1]

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WITH ONE PLATE, ONE TEXT FIGURE, AND FIVE CHARTS

Kaloula picta (Duméril et Bibron), one of the most common frogs in the Philippines, is known in the Tagalog provinces as *palakang kabatchoy, palakang pakansog,* or *palakang bato.* As far as can be ascertained from the literature, *Kaloula picta* is found in the Philippines only. Although de Elera (1895) included Cebu as its habitat, Taylor (1920) found the species in the islands of Luzon, Mindoro, and Negros only.

Literature on the biology of the species is very limited. Taylor (1920) found that the frog in Manila is "incredibly common and may be taken in quantity during its breeding season, after which it disappears and is very rarely found". Villadolid and del Rosario (1930) reported that the frog feeds chiefly on animals, the majority of which are insects.

A closely related temperate-country species, *Kaloula borealis*, was studied by Ju-Ch'i Li (1934) in China. Among other things, he found *Kaloula borealis* to lay eggs in temporary pools formed during the rainy season, so that it was necessary for the eggs to develop rapidly so that the young might escape their hatching places before these pools were completely dried up. Ju-Ch'i Li and Chang-Shan Lin (1935), studying the food and feeding habits of the tadpole and adults of the same species, concluded that the amount and frequency of the rainfall undoubtedly influenced the food supply of the tadpoles whose diet consisted largely of unicellular animals and that the adult *Kaloula borealis* has similar feeding habits to those of frogs and toads.

The objects of the present study are (*a*) to study the post-embryonic development of *Kaloula picta,* (*b*) to make ecological observations on the species with special reference to its breeding habits, and (*c*) to make observations on the feeding habits of the frog.

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[1] Experiment Station contribution No. 1333. Read before the Los Baños Biological Club, November 16, 1939.

The present study was conducted in the Department of Entomology, College of Agriculture, Laguna. The field materials were collected mainly in 1935 and 1936 in Los Baños, supplemented by collections made in Pasig, Rizal. These materials were subsequently studied in the laboratory. Likewise, field observations were made chiefly in Los Baños, supplemented by those made in Pasig, from June, 1935, to June, 1938.

MATERIALS AND METHODS

Developmental studies

For observations on the development of *Kaloula picta*, male and female adult frogs which were ready to breed were caught from pools formed after heavy rains. These were brought to the laboratory and enclosed in cages where they could lay eggs.

The laying cages were outdoor rectangular inclosures of coarse-meshed wire screens, 68 centimeters long, 30 centimeters wide, and 45 centimeters high, closed on all sides to prevent escape of the frogs, but provided with a small door through which the frogs might be introduced or withdrawn. The bottom of the cage was covered with soil in which the frogs might hide during the day. A basin of water was provided at one end of the cage.

The frogs in the cages were fed with termites, beetles, and moths. They were watched closely every night for signs of egg-laying.

As soon as laid, the whole mass of eggs was transferred to battery jars and brought into the laboratory. Samples of the developing eggs were collected every five minutes until the eggs hatched. The samples were preserved in 10 per cent formalin solution. The progress of embryonic development was subsequently observed under the microscope.

The newly-hatched larvae were transferred to large native glazed earthen jars (*tapayan*), of from 500 to 750 liters capacity; these were half-filled with water for observations on the development of the larvae. Bread crumbs, termites, and chick mash were put into these jars every now and then. As soon as the tadpoles transformed into young frogs, they were transferred to another breeding cage, the "maturing cage", where the young frogs were allowed to grow to maturity.

For growth observations, the length measurements and the total weight of 150 tadpoles collected at random were taken daily.

The frogs in the maturing cage were fed termites, which were given them from time to time. They also fed on other insects that were attracted by an insect light-trap, which was set nightly in the cage.

The maturing cage, surrounded by walls about 60 centimeters high and about two meters square, was in the open air. Halved kerosene cans were used in constructing the lower portion of the wall, which was buried about 30 centimeters in the soil. The upper portion of the walls was of galvanized-wire window screen. The soil in the cage along the walls was compacted hard to discourage frogs from digging under it and thereby escaping. A small area (120 centimeters long, 130 centimeters wide, and 30 centimeters deep) for the frogs to hide in during the day was provided in the cage. This was constructed by digging the soil out, refilling the area with sand, and piling over it a few stones the size of a man's head. Water was provided in the cage in two kerosene cans cut open on one side, and buried in about the middle of the cage. The top of the maturing cage was kept open to admit insects which might be attracted thereto.

Breeding and other habits

The breeding habits were observed in the adults confined in the egg-laying cages. The laboratory observations were supplemented by studies in the field.

The sex-ratio was determined from field materials brought in weekly during the progress of the work.

Fecundity was determined by counting the eggs laid by each female in confinement. Percentage of hatch was determined from laboratory and field materials. This percentage was obtained by counting the total number of eggs laid and placing them in a basin of water suitable for hatching. The total number of larvae divided by the total number of eggs and multiplied by 100 per cent was considered the hatching percentage.

The feeding habits were determined by examination of the stomach contents of monthly samples of 100 frogs caught at random in the field. One series was taken for the adult frog, and another series for the young (not tadpole) frog. At first it was thought wise to supplement this with direct observations on frogs which were given special kinds of food, but this plan was subsequently discarded, for, aside from its impracticability, it was believed that the results thus obtained would not be typical of field conditions.

RESULTS AND DISCUSSION

The adult frog

A full technical description of the adult *Kaloula picta* (Duméril et Bibron) was made by Taylor (1920); hence no attempt to redescribe the frog is made here. The male and female frogs are shown in plate 1, figures 1 and 2.

The male can be distinguished from the female roughly by size, and definitely by differences in color markings. Females that have mature eggs can easily be recognized because the eggs are visible through the abdominal wall. Table 1 shows the comparative length (from the tip of the snout to the vent) of the male and the female. Of 353 males measured, the smallest was 32.8 millimeters in length, the largest 51 millimeters, with a mean of 39.6 ± 0.09 millimeters. Of the 450 females studied, the smallest individual was 35.0 millimeters in length, the largest 54.5 millimeters, and the mean was 42.2 ± 0.01. The average adult male was significantly smaller than the average adult female.

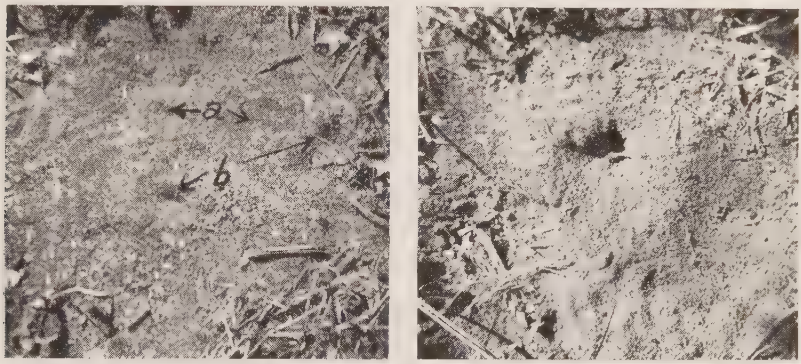

Fig. 1.—Entrances to burrows of *Kaloula picta.* At left, (*a*) indicates entrances to occupied burrows; (*b*) those to deserted burrows. Right, a closer view of the entrance to a deserted burrow.

The most reliable criterion for distinguishing the male from the female is the dark plicate skin on the chin of the male (Pl. 1, fig. 3). Taylor (1920) described the color as green, but in most of the specimens collected in the present study, the color of the chin is black with a greenish drab.

Sex ratio. The sex ratio of the frog is about 1:1. Of a total of 1,793 frogs collected during this study, there were 857 males and 936 females, or 91 males per 100 females.

Chart 1 shows the monthly proportion of the two sexes in 1,200 individuals collected at random, during a period of one year at the rate of 100 individuals per month. It will be seen from the chart that the males greatly outnumbered the females from July to November inclusive, while the females were more abundant from December to June. The period from July to November is within the height of the breeding season of *Kaloula picta* in Los Baños.

In the breeding pools, the males far outnumbered the females. Of 281 frogs collected from breeding pools during several nights, 191, or 68 per cent, were males, while 90, or 32 per cent, were females. Excess of males over females was noted especially during the early part of the evening.

Breeding season and breeding habits. Dissections of female frogs collected every month throughout the entire year showed that females with mature eggs ready to be laid may be found in all months of the year. If this should be taken as a criterion in judging the breeding season, as is usually done with certain other species, this would mean that *Kaloula picta* breeds throughout the year. Actually, however, no eggs were found in the field during March, April, and the early part of May; and the egg-laying season began immediately after the first heavy rains in May and continued up to February of the following year, with the peak of egg-laying occurring from July to October. March, April, and the early part of May are the dry months of the year in Los Baños. That the breeding season coincides with the rainy months is to be expected, since during the entire period of this study *Kaloula picta* has been found always to lay eggs in temporary pools of rain water, and there was never an instance of eggs having been found in rivers or in lakes. In this respect, the species is similar to *K. borealis* as reported by Ju-Ch'i Li (1934).

The breeding habits of the frog are very interesting. Early in the night during the breeding season, the males look for a standing pool of rain water which may serve as a breeding place. Here a number of males gather together—at first only a few but the number gradually increases—and start singing the "mating song" characteristic of the species. The sound is something like "cokak-okak-cokak-okak" repeated over and over. When there are many males in the pool, the concert may be heard at fairly long distances; in one instance, the sound from a particular pool was plainly audible a kilometer away. The mating song apparently attracts the females which are ready to lay eggs. As soon as a female frog reaches the water, she is met by a number of males. Only one male, however, succeeds in pairing with her, and this mounts on her back with its forelimbs clasping her at a point just behind her forelimbs. The unsuccessful males wait for the next females coming to the pool. The community singing may continue till early in the morning.

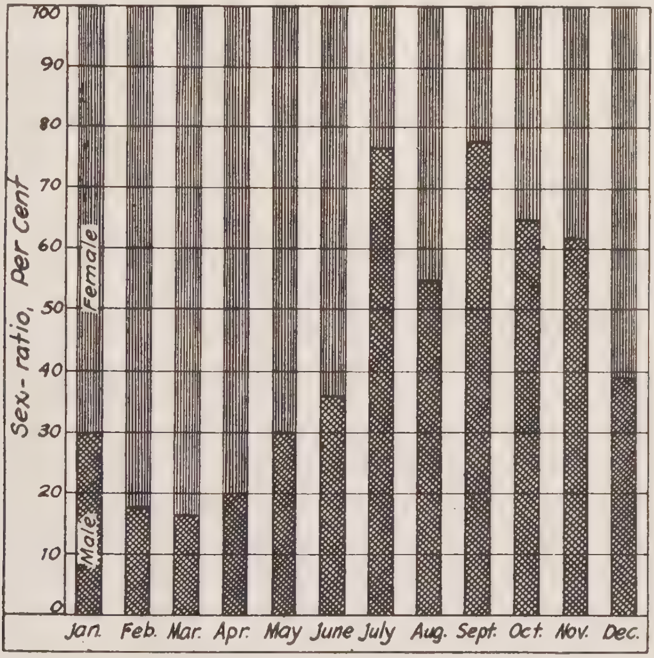

Chart I.—Monthly sex-ratio determinations of adult *Kaloula picta* based on 100 individuals collected at random.

Taylor (1920) observed that in *Kaloula conjuncta* (Peters) the male exudes a sticky substance on his belly which fastens him on the back of the female. In *K. picta* the female and male frogs that are successfully paired soon become similarly attached by a gelatinous substance. For a time, the pair stays floating quietly on the surface of the water. About two or three hours later, however, with the male still on her back, the female begins to lay eggs. About ten to twenty eggs are laid at a time at fairly regular intervals of about ten minutes, until all her eggs are laid.

When the female has laid all her eggs, the sticky substance attaching her to the male loosens up, and the frogs separate. The male floats passively for a short time in the water, after which it leaves the pool. The female also leaves the pool soon after the eggs have been laid.

The eggs are usually laid between two to four o'clock in the morning.

Fecundity. Counts made in the field and in the laboratory of eggs laid by twenty female frogs showed that each female laid from 812 to 4,029 eggs, with a mean of 2250 ± 161.25 eggs. Among several females confined in cages for observation, there was no instance of a frog laying eggs more than once in one year.

The percentage of hatching observed in four batches of eggs collected on separate dates from the field ranged from 89.67 to 98.12 per cent.

Feeding habits of the adult frog. The frog feeds at night, and it may be encountered along fences, along roads, or under a street light searching for food. When stomachs of the adult frogs were opened, the contents consisted of material from three sources: (1) animal, (2) vegetable debris, and (3) sand, gravel, and shells. The composition of the stomach contents of 100 frogs captured at random each month is shown graphically in chart 2. According to the chart, for the years 1935 and 1936, animal matter constituted 80.2 ± 1.03 per cent by volume of the food of the adult frog; vegetable debris, 10.7 ± 0.75 per cent; and sand, gravel, and shell, 9.2 ± 0.63 per cent. Of the 80.2 ± 1.03 per cent animal matter, 52.9 ± 2.30 per cent consisted of insects, while 27.3 ± 1.53 per cent was composed of animal matter other than insects, among which were spiders, sow-bugs, millipeds, and centipeds.

The greatest amount of animal matter was registered in the months of July (91.8 per cent) and June (87.5 per cent); the least, in the months of January (73.7 per cent), September (74.2 per cent), and March (74.6 per cent). Over 80 per cent of the bulk of the stomach contents was of animal matter during the months of February, June, July, October, and November, whereas less than 75 per cent of the bulk was of animal matter during January, March, April, and September.

Vegetable debris was never more than 20 per cent by bulk of the stomach contents. It was highest in September (19.0 per cent) and lowest in July (6.2 per cent). Ten per cent or more of the stomach contents was vegetable debris during the months of January, April, May, August, September, and December; during the other months, this constituent was less than 10 per cent.

The vegetable debris consisted of decaying leaves of grass, banana, and water hyacinth, bits of wood, and decaying leaf-sheaths of banana and, in certain cases, pieces of cloth.

The greatest amount of sand, gravel, and shells was found during March, when they constituted 15.6 per cent of the contents of the stomachs, while the least was found in July (1.97 per cent).

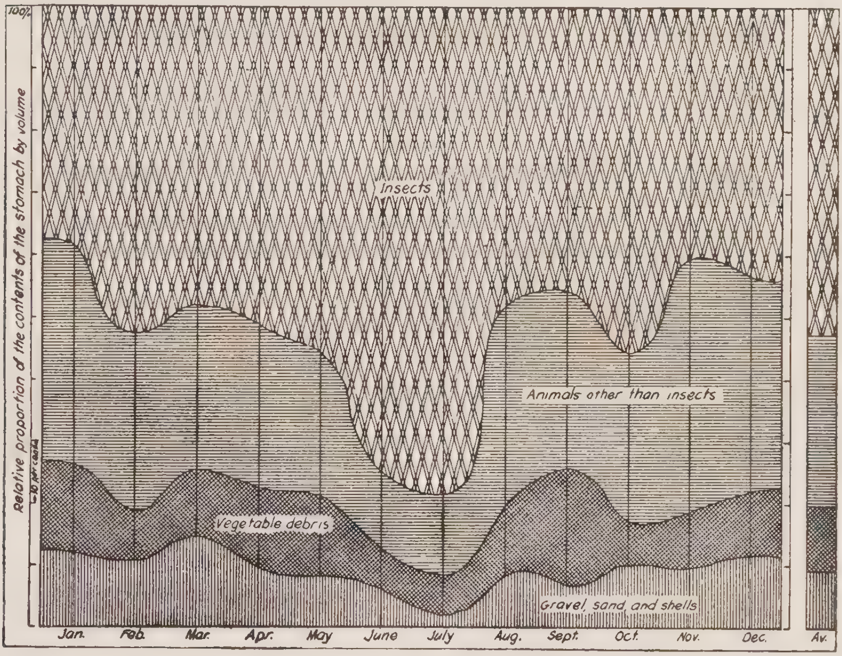

Chart 2.—Monthly composition by volume of the stomach-contents of 100 adult frogs (1935 and 1936).

It is doubtful if the frog purposely took in as food vegetable debris, stones, sand, and shell. The admixture of bits of wood with the vegetable debris is suspicious of these objects having been taken in accidentally.

A volumetric analysis of the insect stomach-contents of 100 adult *Kaloula picta* for each month of the year is shown graphically in chart 3. It will be seen in chart 3 that the orders Coleoptera, Dermaptera, Diptera, Hemiptera, Hymenoptera, Isoptera, Lepidoptera, Odonata, and Orthoptera were recovered from the stomachs. Volumetrically, for the years 1935-1936, Dermaptera (45.35 ± 5.75 per cent) led all other orders in importance as a food item of *Kaloula picta*. It was followed by Coleoptera (13.21 ± 1.92 per cent), Isoptera (11.41 ± 2.10 per cent), Orthoptera (11.15 ± 1.75 per cent), and Hymenoptera (10.86 ± 2.13 per cent). Odonata were the least significant, these constituting but 0.45 ± 1.45 per cent of the insect bulk in the stomachs; it was followed in an increasing order by Hemiptera (1.09 ± 0.36 per cent), Diptera (1.60 ± 0.32 per cent), Lepidoptera (4.88 ± 1.69 per cent), and Hymenoptera (10.86 ± 2.13 per cent).

Table 2 shows the families or groups represented in the various insect orders and the number of individuals of each family or group recovered each month from random samples of 100 stomachs of adult frogs. There was no attempt made to identify the species found.

It may be seen in table 2 that Hymenoptera (practically all of which were ants) outranked all other orders in numerical importance as food of *Kaloula picta* for the whole year, there being 5,808 hymenopterous insects or 39.26 per cent of the total number of identifiable insects in the stomachs. The Hymenoptera are followed in numerical importance by Isoptera (3,715 individuals, or 24.86 per cent), Dermaptera (2,974 individuals, or 19.83 per cent), and Coleoptera (1,704 individuals, or 11.40 per cent). These four orders comprised 95.35 per cent of the total number of insects taken in as food by the adult. The orders Odonata (14 individuals, or 0.09 per cent), Hemiptera (77 individuals, or 0.11 per cent), Lepidoptera (108 individuals, or 0.72 per cent), Orthoptera (237 individuals, or 1.59 per cent), and Diptera (309 individuals, or 2.00 per cent) were more or less insignificant items, and together, they constituted but 4.51 per cent, numerically, of the insect diet of the frog.

Isoptera, which comprised 24.86 per cent of the total number of insects recovered, were most abundant in frogs caught during the months of July and August, and least abundant or absent in the stomach during the months of January, February, March, and April. The termites recovered were mostly workers and soldiers.

The order Coleoptera was represented by the families Carabidae, Calandridae, Cerambycidae, Curculionidae, Chrysomelidae, Dermestidae, Dryopidae, Elateridae, Nitidulidae, Passalidae, Scarabaeidae, Staphylinidae, Tenebrionidae, and Trogidae. Tenebrionidae and Elateridae (913 and 453 individuals, respectively) comprised 1,366 (or 80.16 per cent) of the 1,704 beetles encountered during the whole year. The frogs caught during the months of December, January, February, March, and April (relatively drier months) were especially rich in beetles, 1,213 (or 71.18 per cent) of the 1,704 beetles for the whole year having been recovered from them during these five months. The frogs caught during the more rainy months of July to November contained relatively few beetles.

The order Diptera was represented by Culicidae and Muscidae. Of the Orthoptera, the families Blattidae, Gryllidae, Acridiidae, and Tettigoniidae were recovered from the stomachs. Adult Lepidoptera, of the families Hesperidae, Noctuidae, and Pyralidae, were found in the stomachs of the adult frog. In addition to these, caterpillars were also found.

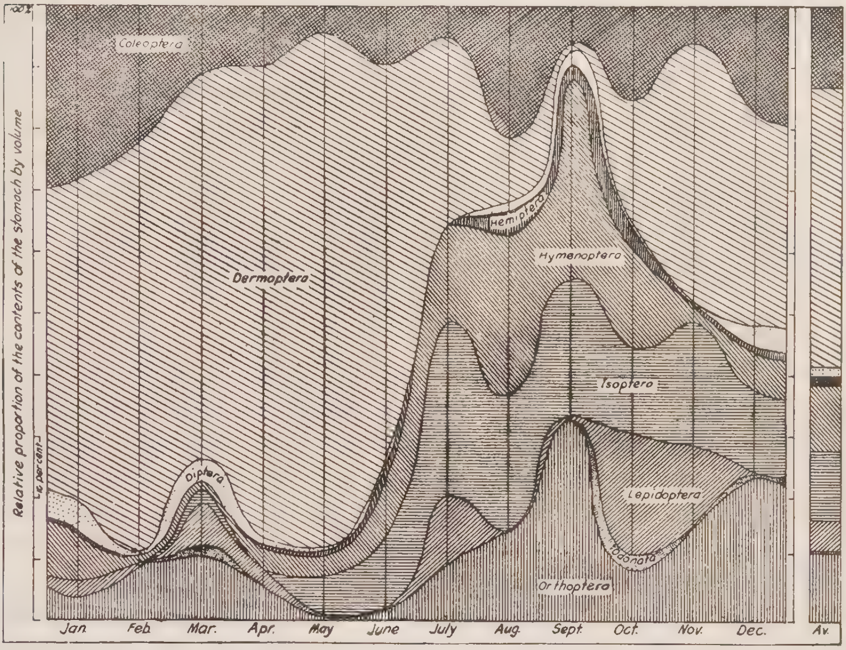

Chart 3.—Monthly composition by volume of the insect portion of the stomach-contents of 100 adult frogs (1935 and 1936).

Hiding habits. The frog is active only at night and hides during the day. Decaying logs, coconut husks which are partly buried in the ground, decaying banana trunks, loose stones, and logs on the ground have been found to be attractive hiding places for *Kaloula picta.* If these are not available, the frog digs into the ground to make a burrow where it spends the day. Along fences, at the base of trees or in isolated grass protected from the heat of the sun, or in gardens where the ground is soft and moist are favorite locations for burrows. The depth of the burrow varies from about one centimeter to about a meter. When in the open and when the soil is soft, the burrows are deep; but underneath protecting objects or when the soil is hard, they are shallow.

The burrows are straight and inclined at an angle of about 65°. The frog uses its hind limbs in digging the burrow, loosening and pushing the soil particles with its toes. The bottom of the burrow is enlarged into an acinus. While in the act of digging, the frog inflates itself; resting in the acinus, it is deflated and lies flat on its belly.

While the frog is still inside, the entrance of the burrow is covered with the loose particles of soil that the frog has dug. This entrance is left gaping open when the frog deserts the burrow. Figure 1 shows (*a*) entrance to burrow in which the frog still is and (*b*) the gaping openings of burrows deserted by *Kaloula picta*; a closer view of the entrance to a deserted burrow is also shown.

The egg

The newly laid eggs float close to each other, arranged in a single layer in a more or less circular area on the surface of the water. Each egg is enclosed in a gelatinous capsule. In frogs, according to Parker and Haswell (1921), the male sheds his spermatic fluid over the eggs, and a spermatozoon makes its way through the gelatinous capsule in order to impregnate the egg.

The egg proper is spherical. Measurements of 2,207 eggs freshly deposited by one female showed that the eggs ranged from 1.0 millimeter to 1.3 millimeters in diameter, the mean diameter being 1.2 ± 0.0001 millimeters. A freshly laid egg (Pl. 1, fig. 6) is distinctly divided into a dark, animal, and a light, vegetal, hemisphere.

The egg capsule in a freshly laid egg is a transparent, gelatinous sphere, where the egg proper is more or less centrally located. The diameter of 509 measured egg capsules, all from the same female, ranged from 3.5 millimeters to 5.2 millimeters, with a mean diameter of 4.4 ± 0.01 millimeters.

Development of the embryo. The development of the embryo in *Kaloula picta* closely follows those described for other species of frogs, *Kaloula borealis*, for example, as described by Ju-Ch'i Li (1934), allowing possible differences in time for the appearance of characteristic features of the embryo. In *Kaloula picta* under conditions that existed in the laboratory, the two-cell stage was observed in the eggs collected 30 minutes after oviposition; the four-cell stage, one hour after; the eight-cell stage, one hour and fifty-five minutes; and the sixteen-cell stage, two hours and thirty-five minutes. The embryo hatched thirteen to fifteen hours after oviposition. Plate 1, figures 4 to 8, shows the embryo at different periods of development.

The egg proper increased in size as embryonic development progressed, so that at the thirteenth hour, when the egg was about to hatch, the diameter was over twice that at the fourth hour after oviposition, as may be seen in table 3. The capsule, however, remained practically unchanged in size during embryonic development, as may be seen also in the same table.

The larva and the young frog

Larval development. Immediately after hatching, the larva (Pl. 1, fig. 9) measured 3.1 to 3.3 millimeters in length. Its tail was very short when compared to its trunk. There was no mouth, but the oral suckers, rudiments of the optic vesicle and the pronephric eminence were visible on it. The larva, which remained enclosed in the egg capsule, was slightly active. Since the mouth was not yet developed, the newly hatched larva possibly drew its nutrition from the yolk stored in the egg, which, by then, was enclosed by the abdominal wall. Up to the time immediately preceding hatching, the egg floated on the surface of the water; the newly hatched larva in the egg capsule sank to the bottom of the pond where it remained until twelve hours later when the capsule was ruptured owing to the continuous wiggling of the larva. The larva then rose to the surface of the water.

Eight hours after hatching, the external gills and the oral suckers were well developed. The optic vesicle was noticeable, and the anal pit showed signs of development.

Nineteen hours after hatching, the tadpole was observed to have a much lengthened tail, prominent gills, and opened mouth and anus, although the eyes were not yet fully developed. The larva fed on the egg capsule from which it had escaped previously, swam actively, or attached itself, by means of the suckers, to floating objects or blades of grass which were partly submerged.

Thirty-six hours after hatching, the head had not increased in size very markedly from that of a newly hatched larva; the eyes were very prominent, the suckers and external gills were still present, and a skin fold (rudiment of the operculum) appeared on each side of the head in front of the external gills.

Seventy-two hours after hatching, the larva had grown enormously in size and had an enlarged head. The intestines had increased greatly in length. From this time on, the externally visible changes in the developing tadpole consisted of change in size, the development of the limbs, and the resorption of the tail. The hind limbs appeared prominently on the twelfth day after hatching, but attained full development in the tadpole thirteen days after hatching.

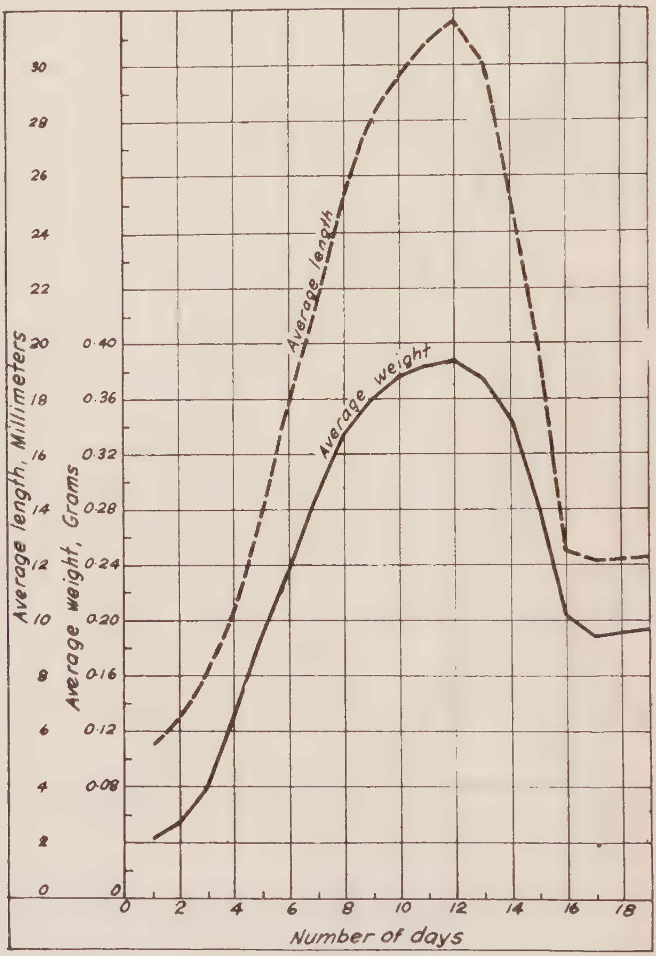

Chart 4.—Average daily growths in weight and length of 150 tadpoles.

The fore limbs, the primordia of which were visible underneath the body integument twelve days after hatching, was observed to have broken through the skin on the fourteenth day after hatching; it was fully developed three days later. On the seventeenth day after hatching, the alimentary canal decreased in length, and the gill clefts closed. Resorption of the tail commenced late on the thirteenth day after hatching, and on the seventeenth day all that remained of the tail was a mere stub.

The larva began to leave the water sixteen days after hatching; and on the eighteenth day, when the young frog had attained the features of the adult frog, its habitat was largely terrestrial.

Larvae of different ages are shown in plate 1, figures 9 to 15.

Growth of larva. Table 4 presents the average daily length and weight of one hundred and fifty larvae selected at random. The measurements were started one day after the larvae hatched and were continued until the young tadpoles became young frogs. The results are also presented graphically in chart 4.

It may be seen from table 4 and chart 4 that the tadpoles increased steadily in length until the twelfth day after hatching, when they attained their maximum length of 31.53 millimeters. The total increase in length was 25.85 millimeters with an average daily increase of 2.35 millimeters. The greatest rate of increase occurred during the fifth, sixth, seventh, and eighth days after hatching when average daily increases of 3.37 to 4.25 millimeters for each of the one hundred and fifty larvae were observed.

Thirteen days after hatching, the tadpoles decreased in length. This decrease was steady for five consecutive days, and it totalled 20.24 millimeters. This decrease in length was due to the resorption of the tail which began on the thirteenth day and was completed on the eighteenth day after hatching. An increase in the length of the young frog was noted on the nineteenth day after hatching, or a day after the tail was completely resorbed.

It may be seen in table 4 and chart 4 that the curve in the weight of the developing larvae followed that of the length. The larvae steadily increased in weight until the thirteenth day after hatching when the tadpoles were heaviest. Up to the thirteenth day, the total increase in weight was 0.35 gram, or a daily average increase of 0.02 gram. From the thirteenth day, and consecutively for five days—the whole duration of the resorption of the tail—the tadpoles steadily decreased in weight, the total loss for the five days being 0.20 gram, or an average daily decrease of 0.04 gram. There was an increase in weight on the nineteenth day after hatching, or immediately after the young frog stage was attained.

Food of young Kaloula picta

The stomach contents of young *Kaloula picta* consist of insects, animals other than insects, vegetable debris, and stones, sand, and dead shells. The vegetable debris is composed of decaying leaves.

Chart 5 shows the stomach contents of random samples of 100 young frogs for each month during 1935 and 1936. No contents were shown for the months of June and July for the reason that no young frogs could be found during these months. It will be noted that 67.24 per cent of the stomach contents for the whole year consisted of animal matter, of which 60.75 ± 1.53 per cent were insects; 20.79 ± 1.42 per cent was vegetable debris, and 11.97 ± 0.53 per cent was composed of stones, sand, and dead shells.

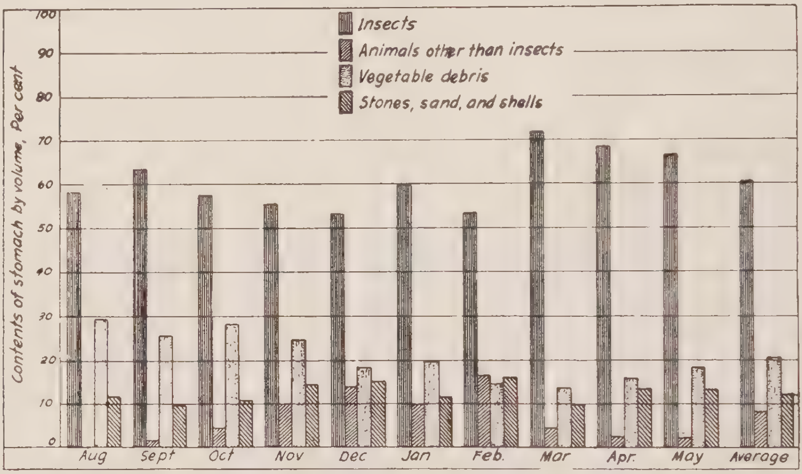

Chart 5.—Monthly composition by volume of the contents of 100 young frogs (not tadpoles) (1935 and 1936).

Chart 5 shows, also, that the insects in the stomachs were most numerous during the months of March (71.61 per cent), April (68.18 per cent), May (66.18 per cent), September (63.41 per cent), and August (58.62 per cent). The insects in the stomach contents were less in December (53.32 per cent), February (53.48 per cent), November (55.41 per cent), and October (56.94 per cent).

Among the animals other than insects which were found in the stomachs were small crustaceans (Amphipods, Copepods, and Ostracods), spiders, scorpions and centipedes.

Table 5 presents the insect orders which were found in the stomach of young *Kaloula picta* during the years 1935 and 1936. It also gives the volume by percentage of the orders. The orders were Coleoptera, Dermaptera, Diptera, Hemiptera, Hymenoptera, Isoptera, Odonata, and Orthoptera. Of these orders, the greatest bulk for the period was Dermaptera (30.37 ± 5.96 per cent), followed by Coleoptera (20.45 ± 3.68 per cent), Isoptera (20.21 ± 3.31 per cent), and Hymenoptera (19.78 ± 4.2 per cent). Odonata (0.06 ± 0.45 per cent) and Hemiptera (0.44 ± 0.63 per cent) were insignificant.

Table 6 presents the number of individuals of the different families found in monthly samples of 100 stomachs of young *Kaloula picta*. As in the adult stage, no attempt was made to identify the species of the insects.

It may be seen in table 6 that Hymenoptera (3,150 individuals, or 38.06 per cent of the insects found in the stomachs) outranked all other orders in numerical importance as food of *Kaloula picta* for the whole year. Isoptera (2,395 individuals, or 28.91 per cent) comes next, followed by Coleoptera (1,322 individuals, or 15.98 per cent) and Dermaptera (1,226 individuals, or 14.81 per cent). In the adult frog, this is also the order of numerical importance of these four orders. Hymenoptera, Isoptera, Coleoptera, and Dermaptera together constituted 97.76 per cent of the stomach contents of the young frog. Odonata (with only a single representative), Hemiptera (20 individuals, or 0.24 per cent), Orthoptera (42 individuals, or 0.51 per cent), and Diptera (120 individuals, or 1.45 per cent) were insignificant items in the food of the young frog. These were also insignificant in the adult frog. The order Lepidoptera, which was found in the stomach of the adult frog, was not represented in the stomach contents of the young frog.

On the whole, the young frog was like the adult in its feeding habits and food preferences.

SUMMARY AND CONCLUSIONS

1. The adult female of *Kaloula picta* (Duméril et Bibron) is significantly larger than the adult male. The adult male can be recognized externally by the dark plicate skin on its chin, neither of which characters is found in the female.

2. During the years 1935 and 1936, the males were found in Los Baños and vicinity to be more abundant during the months of July to November; the females, from December to June.

3. This frog was found to breed only in temporary pools of rain water.

4. Frogs in cages laid but one batch of eggs in one breeding season, during which each female produced 812 to 4,029 eggs, with an average of 2,250 eggs.

5. During the period under consideration, the breeding season in Los Baños began soon after the heavy rains in May and ended in February, with the peak occurring from July to October. This factor doubtless explains the higher male ratio observed from July to November.

6. The stomach contents of the adult frog consisted of 80.17 ± 1.03 per cent by bulk of animal matter, 10.67 ± 0.75 per cent vegetable debris, and 9.16 ± 0.64 per cent sand, gravel, and shell.

7. Insects constituted 52.88 ± 2.30 per cent of the bulk of the stomach contents; they belonged to the orders Coleoptera, Dermaptera, Diptera, Hymenoptera, Isoptera, Lepidoptera, Odonata, and Orthoptera. Dermaptera, Coleoptera, Isoptera, Orthoptera, and Hymenoptera were the more bulky items of food of the adult *Kaloula picta*. Hymenoptera (practically all ants), Isoptera, Dermaptera, and Coleoptera were the most numerous insects in the stomachs of the adult frog, in the order that they are named; together they constituted 95.35 per cent of the total number of insects in the stomachs.

8. The Coleoptera found in the stomach of the adult frog belonged to the families Carabidae, Calandridae, Cerambycidae, Curculionidae, Chrysomelidae, Dermestidae, Dryopidae, Elateridae, Nitidulidae, Passalidae, Scarabaeidae, Staphylinidae, Tenebrionidae, and Trogidae. Tenebrionidae and Elateridae comprised 80.16 per cent of the beetles recovered during the whole year.

9. The dipterous families Culicidae and Muscidae, the hemipterous families Lygaeidae, Naucoridae, Pentatomidae, and Pyrrhocoridae, the hymenopterous family Larridae (also ants), the lepidopterous families Hesperidae, Noctuidae, and Pyralidae, and the Orthopterous families Acridiidae, Blattidae, Gryllidae, and Tettigoniidae were represented in the adult stomach.

10. The adult frog is exclusively nocturnal, foraging and breeding at night, but hiding either in burrows which it makes in the

ground, or underneath fallen trunks of trees or loose stones during the day.

11. The eggs, which are inclosed in a gelatinous capsule, float in mass and in a single layer on the surface of the water. They hatch thirteen to fifteen hours after oviposition.

12. The egg increases slightly in size during embryonic development.

13. The larva completes its metamorphosis in eighteen days.

14. The tadpole steadily increases in length and weight from hatching to the time resorption of the tail begins, loses weight and decreases in length during resorption, and again increases in both length and weight immediately after the young frog takes form.

15. The feeding habits of the young frog, after completion of the tadpole stage, are similar to those of the adult.

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EXPLANATION OF PLATE

(Magnifications indicated refer to original figures)

Fig. 1. Adult female, ventral aspect (×2).
Fig. 2. Adult male, dorsal aspect (×2).
Fig. 3. Plicate dark chin of the male (×2).
Fig. 4. Egg, 15 minutes after being laid (×30).
Fig. 5. Egg, 30 minutes after being laid (×30).
Fig. 6. Egg, 8 hours and 35 minutes after being laid (×30).
Fig. 7. Egg, 9 hours and 10 minutes after being laid (×30).
Fig. 8. Egg, 10 hours and 35 minutes after being laid (×30).
Fig. 9. A newly-hatched larva (×21).
Fig. 10. Larva, 29 hours after hatching (×21).
Fig. 11. Larva, 40 hours old (×21).
Fig. 12. Larva, 12 days and 4 hours old (×5).
Fig. 13. Tadpole, 15 days and 20 hours old (×8).
Fig. 14. Tadpole, 17 days, 8 hours and 30 minutes old (×8).
Fig. 15. Young frog, 18 days after hatching (×8).

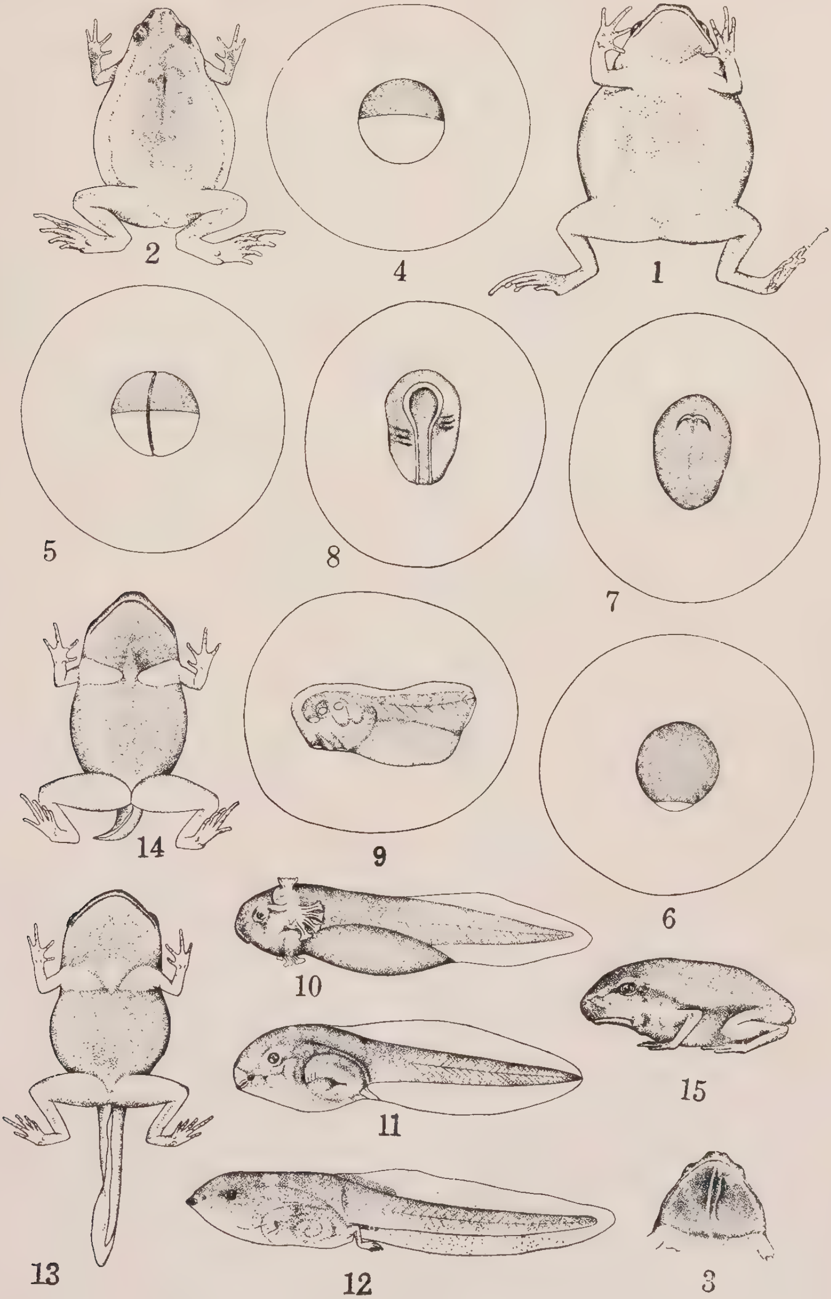
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PLATE 1

TABLE 1

Lengths (from snout to vent) of the adult male and female

LENGTH IN MILIMETERS	FREQUENCY	
	Number of males	Number of females
32.5–33.4	1	
33.5–34.4	3	
34.5–35.4	8	6
35.5–36.4	10	8
36.5–37.4	16	19
37.5–38.4	33	23
38.5–39.4	67	25
39.5–40.4	87	45
40.5–41.4	31	27
41.5–42.4	46	54
42.5–43.4	32	61
43.5–44.4	10	51
44.5–45.4	7	57
45.5–46.4	0	19
46.5–47.4	0	20
47.5–48.4	0	14
48.5–49.4	1	8
49.5–50.4	0	8
50.5–51.4	1	0
51.5–52.4		2
52.5–53.4		0
53.5–54.4		2
54.5–55.4		1
Total............	353	450
Mean...........	39.63 ± 0.09	42.22 ± 0.11

$$D_m \pm E_{dm} = 2.5918 \pm 0.1078$$

TABLE 2

Insects taken from monthly samples of stomach contents of adult Kaloula picta (by number taken from 100 stomachs per month) (1936)

FAMILIES	NUMBER OF INDIVIDUALS												TOTAL
	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	
Order Coleoptera													
Carabidae	4	6	11	2	2								25
Calandridae								10		4		2	16
Cerambycidae				2						2			4
Curculionidae		10	2	1									13
Chrysomelidae				3	2			3					8
Dermestidae		2											2
Dryopidae				15		5							20
Elateridae	112	98	35	48	17	39				14	14	76	453
Nitidulidae	5	9	3	3	11	9	4				7	23	74
Passalidae										2			2
Scarabaeidae			2				10	5	4	4			25
Staphylinidae	9	12	10	58	5	7	8			5	12	12	138
Tenebrionidae	209	158	59	67	36	83	26	54	10	59	17	135	913
Trogidae			8								1	2	11
Total	339	295	130	199	73	143	48	72	14	90	51	250	1704
Per cent	23.49	35.67	24.76	22.06	9.48	8.58	1.54	5.60	1.88	6.89	5.72	17.15	11.40
Order Dermaptera													
Forficulidae	280	341	261	612	358	393	258	53	4	101	134	179	2974
Per cent	19.39	41.23	49.72	67.85	46.49	23.58	8.25	4.13	0.54	7.73	15.02	12.28	19.83

TABLE 2 (Continued)

FAMILIES	NUMBER OF INDIVIDUALS												TOTAL
	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	
Order Diptera													
Culicidae	16	42				1			5	2	30	25	121
Muscidae	46	11	27	14	10	3		3	4	7	38	25	188
Total	62	53	27	14	10	4		3	9	9	68	50	309
Per cent	4.29	6.41	5.14	1.55	1.30	0.24		0.23	1.21	0.69	7.62	3.43	2.00
Order Hemiptera													
Belostomatidae	6												6
Lygaeidae				5	3	3							11
Naucoridae								3	2				5
Pentatomidae						4			1	9		4	18
Pyrrhocoridae	3				1	9		8	4	12			37
Total	9			5	4	16		11	7	21		4	77
Per cent	0.62			0.56	0.52	0.96		0.86	0.94	1.61		0.27	0.11
Order Hymenoptera													
Formicoidae	721	112	25	48	149	956	1480	458	392	736	124	595	5796
Larridae				1				11					12
Total	721	112	25	49	149	956	1480	469	392	736	124	595	5808
Per cent	49.94	13.55	4.76	5.43	19.35	57.34	47.34	36.53	52.62	56.36	13.90	40.81	39.26
Order Isoptera													
Termitidae			55		174	150	1294	662	274	290	471	345	3715
Per cent			10.48		22.60	9.00	41.39	51.56	36.78	22.20	52.80	23.66	24.86

TABLE 2 (Continued)

FAMILIES	NUMBER OF INDIVIDUALS												TOTAL
	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	
Order Lepidoptera													
Hesperidae							14						14
Noctuidae	3				1		4			33	21		62
Pyralidae							8						8
Caterpillars (unidentified)	8	1	5	6			2		2				24
Total	11	1	5	6	1		28		2	33	21		108
Per cent	0.76	0.12	0.95	0.67	0.13		0.90		0.27	2.53	2.36		0.72
Order Odonata													
Zygoptera										7			7
Anisoptera			2							2		3	7
Total			2							9		3	14
Per cent			0.38							0.69		0.21	0.09
Order Orthoptera													
Acrididae		5					2		8		1	5	21
Blattidae	13	14	7	4		2	8	10	26	14	20	22	140
Gryllidae	9	6	13	13	1	3	8	4	6	3	2	5	73
Tettigoniidae									3				3
Total	22	25	20	17	1	5	18	14	43	17	23	32	237
Per cent	1.53	3.02	3.81	1.88	0.13	0.30	0.58	1.09	5.76	1.30	2.58	2.19	1.59
Total number	1444	827	525	902	770	1667	3126	1284	745	1306	892	1458	14,946

TABLE 3

Diameter of the egg and egg capsule during embryonic development. (Hatching took place after thirteen hours)

TIME AFTER OVIPOSITION	EGG			EGG CAPSULE		
	Number measured	Average diameter	Increase in diameter	Number measured	Average diameter	Increase in diameter
hrs.		*mm*	*mm.*		*mm.*	*mm.*
4	50	1.22		50	4.56	
5	50	1.29	0.07	50	4.57	0.01
6	50	1.35	0.06	50	4.57	0.00
7	50	1.42	0.07	50	4.57	0.00
8	50	1.47	0.05	50	4.57	0.00
9	50	1.53	0.06	50	4.57	0.00
10	50	1.61	0.08	50	4.58	0.01
11	50	1.77	0.16	50	4.58	0.00
12	50	2.22	0.55	50	4.62	0.04
13	50	2.89	0.67	50	4.62	0.00
Total			1.77			0.06

TABLE 4

Average daily growth of Kaloula picta tadpoles

DATE OBSERVED	AGE OF TADPOLES	NUMBER OF TADPOLES OBSERVED	LENGTH		WEIGHT	
			Average length	Change	Average weight	Change
1936	*days*		*mm.*	*mm.*	*gm*	*gm.*
7—VIII [a]	1	150	5.68		0.04	
8—VIII	2	150	6.39	+0.71	0.06	+0.02
9—VIII	3	150	8.11	+1.72	0.08	+0.02
10—VIII	4	150	10.23	+2.12	0.13	+0.05
11—VIII	5	150	13.60	+3.37	0.18	+0.06
12—VIII	6	150	17.85	+4.25	0.24	+0.05
13—VIII	7	150	21.29	+3.44	0.29	+0.05
14—VIII	8	150	25.20	+3.91	0.33	+0.05
15—VIII	9	150	28.07	+2.87	0.36	+0.03
16—VIII	10	150	29.61	+1.54	0.38	+0.02
17—VIII	11	150	30.91	+1.30	0.38	+0.01
18—VIII	12	150	31.53	+0.62	0.39	+0.00
Total increase				+25.85		+0.35
19—VIII [b]	13	150	30.19	—1.34	0.37	—0.01
20—VIII	14	150	25.20	—4.99	0.34	—0.03
21—VIII	15	150	19.77	—5.43	0.28	—0.06
22—VIII	16	150	11.55	—8.22	0.20	—0.08
23—VIII	17	150	11.29	—0.26	0.19	—0.01
Total decrease				—20.24		—0.20
24—VIII [c]	18	150	11.30	+0.01	0.19	+0.00
25—VIII	19	150	11.44	+0.14	0.19	+0.00

[a] Eggs hatched 6—VIII—1936.
[b] Resorption of tail has begun.
[c] No more tail—now a young frog.

TABLE 5

Insect orders found in the stomachs of young Kaloula picta (per cent by volume of contents of 100 stomachs) (1935-1936)

ORDER	AUG.	SEPT.	OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY	AVERAGE
	per cent	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*
Coleoptera	2.35	12.31	35.62	38.03	9.12	40.11	32.70	15.17	11.54	7.57	20.45 ± 3.68
Dermaptera	3.92	0.40	1.23	11.22	38.70	40.03	51.88	56.51	46.71	53.07	30.37 ± 5.96
Diptera	1.57	0.40	1.50	6.64	0.89	1.57	1.83		6.66	4.37	2.54 ± 0.59
Hemiptera				1.87			0.41	2.13			0.44 ± 0.63
Hymenoptera	35.69	66.27	31.10	16.07	12.97	12.68	2.44	7.17	5.84	7.54	19.78 ± 4.20
Isoptera	56.47	19.28	27.81	14.96	8.52	0.62		18.40	29.25	26.76	20.21 ± 3.31
Odonata								0.59			0.06 ± 0.45
Orthoptera		1.34	2.74	11.21	29.80	4.97	10.74			0.69	6.15 ± 2.40

TABLE 6

Analysis of the insects taken from monthly samples of 100 stomachs of young (not tadpole) Kaloula picta (1935-1936)

FAMILIES	NUMBER OF INDIVIDUALS										
	August	September	October	November	December	January	February	March	April	May	TOTAL FOR YEAR
Order Coleoptera											
Carabidae							2				2
Cerambycidae				2							2
Chrysomelidae										3	3
Dryopidae							8				8
Elateridae	12	25	38	20	12	79	50	18	12	48	314
Nitidulidae		76	97				9	29	24	12	247
Scarabaeidae				7					4		11
Staphylinidae	3	73	37	11	37	10	9	33	8	35	256
Tenebrionidae		21	46	78	38	182	110	44	28	32	479
Total	15	195	218	118	87	271	188	124	79	130	1322
Per cent	2.63	19.94	28.80	28.38	18.16	20.83	41.87	13.29	8.40	8.36	15.98
Order Dermaptera											
Forficulidae	10	3	7	38	78	172	167	258	204	289	1226
Per cent	1.75	0.31	0.93	9.14	16.28	13.22	37.19	27.65	21.68	18.59	14.81
Order Diptera											
Culicidae			11	2							13
Muscidae (adults)			3	10							13
Maggots	3	1			8	20	5		25	32	94
Total	3	1	14	12	8	20	5		25	32	120
Per cent	0.53	0.10	1.85	2.88	1.67	1.54	1.11		2.66	2.06	1.45

TABLE 6 (continued)

FAMILIES	NUMBER OF INDIVIDUALS										TOTAL FOR YEAR
	August	September	October	November	December	January	February	March	April	May	
Order Hemiptera											
Naucoridae								7			7
Pyrrhocoridae						3					3
Pentatomidae				3				7			10
Total				3		3		14			20
Per cent				0.72		0.23		1.50			0.24
Order Hymenoptera											
Formicoidae	408	666	345	102	194	808	80	228	80	239	3150
Per cent	71.45	68.10	45.57	24.52	40.50	62.11	17.82	24.44	8.58	15.37	38.06
Order Isoptera											
Termitidae	135	112	172	140	102	12		308	552	862	2395
Per cent	23.64	11.45	22.72	33.65	21.30	0.92		33.01	58.70	55.43	28.91
Order Odonata											
Anisoptera								1			1
Per cent								0.11			0.04
Order Orthoptera											
Acridiidae				2	3						5
Blattidae			1		7	8	6			3	25
Gryllidae		1		1		7	3				12
Total		1	1	3	10	15	9			3	42
Per cent		0.10	0.13	0.72	2.09	1.15	2.01			0.19	0.51
Total number	571	978	757	416	479	1301	449	933	940	1555	8276

A STUDY OF THE MARKETING OF LANZONES IN LAGUNA [1]

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WITH ONE CHART

Lanzones,[2] although occupying only the tenth place in respect to area under cultivation, is third in money value among the leading fruits produced in the Philippines (table 1). Most of the lanzones on the market are produced in the province of Laguna; in fact, in 1937, Laguna had under cultivation 187,550, or 45.47 per cent, of the 412,490 lanzones trees in the Philippines (tables 1 and 3). Dans (1929) states that the other provinces producing lanzones are Agusan, Bohol, Camarines Norte, Cavite, Cebu, Davao, Leyte, Misamis, Oriental Negros, Samar, and Tayabas. But the fruit produced in these provinces, according to him, is not as sweet as that produced in the province of Laguna.

There is always a good market for lanzones. But even though the whole season lasts from July to November, the greater part of the fruit goes to the market within less than a month; hence the markets are often glutted during the flush of the season about the middle of August. Because of this fact, and in view of the possibility of canning and storing a part of the seasonal production of the fruit, this study is important. A knowledge of the factors affecting the marketing and distribution of this product would serve as a basis for recommending improvements.

The quality of lanzones is believed to vary according to the locality. This has an important appeal to the buyers of the fruit. For example, since the town of Paete is believed to be the home of the sweetest lanzones in the province, although sweet lanzones are also produced in the towns near Paete, such as Pakil and Loñgos, people who buy the fruit think that all of the fruit of this quality is produced in the town of Paete. Consequently, sellers attract buyers by advertising it as having come from Paete. As to quality, Mendiola (1922) states that there are two types or varieties of lanzones known, namely, the sweet and the sour. These are both produced in Laguna.

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[1] Experiment Station contribution No. 1334.

[2] "Lanzones" refers to the mature fruit of the lanzones tree. Spelled the same in singular and in plural.

It is said that the yield of lanzones trees can be estimated very closely at the time the trees are in blossom. This practice has made it possible for lanzones to be sold by contract long before the fruit is ready for harvesting. How this is done will be discussed later.

Orgas (1936) studied the cost of production of lanzones on a hectare of land planted with 204 trees. He reports that it costs ₱196.38 to produce 200 *kaings*[3] of lanzones from 204 trees on one hectare. Assuming that the fruit is sold at ₱5.00 per *kaing*, Orgas estimated that the total selling price of the lanzones produced from one hectare would be ₱1,000.00. If from this amount the cost of producing the lanzones were deducted, there would be left a net profit of ₱803.62. The estimates reported by Orgas were distributed as follows:

Description of operation	*Approximate cost per hectare*
1. Expenses for pruning	₱35.00
2. Interest on value of land (six per cent of ₱500.00)	30.00
3. Land tax	4.38
4. Picking 200 *kaings* of lanzones	20.00
5. Collecting the lanzones	5.00
6. Crating the lanzones	2.00
7. Cost of *kaings* (200 @ ₱0.50)	100.00
Total expenses	₱196.38
Value of 200 *kaings* of lanzones at ₱5.00 per *kaing*	₱1,000.00
Net profit per hectare	₱803.62

The above figures would be equivalent to a cost of production of ₱0.98 per *kaing*, or a net profit of ₱4.02. It should be noted, however, that the figures reported by Orgas do not include all of the costs of marketing the product; consequently, the net profit of ₱4.02 per *kaing* is rather too large.

Dans (1929) made a study of the lanzones industry in Laguna, but he did not make a detailed analysis of the method and costs of marketing the product. He states that most of the lanzones produced in the province of Laguna are sold under contract and are paid for by the buyers immediately after the appearance of the flowers on the trees or before the fruit matures.

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[3] A *kaing* is a Tagalog word which refers to a basket or crate which contains from 1,500 to 1,800 lanzones, or from 28 to 30 kilograms of the fruit.

San Pedro (1936) made studies of the storage-temperature requirements of lanzones with a view to prolonging the marketable life of the fruit, which can be kept under ordinary conditions, according to this authority, for not more than four days. He found that ripe lanzones can be kept in good marketable condition for seven days by covering the fruit with sawdust. Storing the fruit at a temperature of 13 to 15.5 degrees C., according to the author, kept it in excellent marketable condition for thirteen days. He also recommended the storing of the fruit immediately after picking because this was found to minimize the spoilage of the product by one-third to two-thirds, when compared with fruit that was kept at room temperature for two days before being placed in storage.

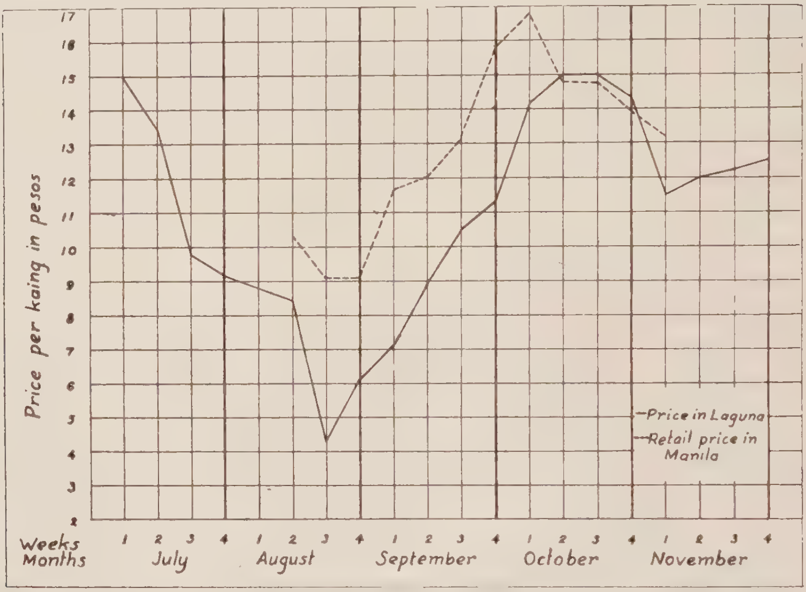

Chart 1.—Showing trend of weekly prices of lanzones in Laguna and Manila for the 1938 season.

The objects of the present work were: (*a*) to determine the methods used and the channels involved in the marketing of lanzones produced in the province of Laguna, (*b*) to determine the cost of marketing this product, and (*c*) to determine what proportion of the consumer's price for this product is received by the grower.

The survey was conducted from December 20, 1937, to January 8, 1938, from March 15 to May 1, 1938, from December 22, 1938 to January 5, 1939, and from March 17 to May 9, 1939. The study took place in the province of Laguna and covered the leading lanzones-producing towns of San Pablo, Paete, Pakil, Loñgos, Santa Cruz, Nagcarlan, Rizal, Majayjay, Lilio, Magdalena, and Calauan. The lanzones crop of 1938 was the subject of inquiry for the survey.

MATERIALS AND METHODS

From the municipal treasurers of the towns mentioned above, a list of lanzones growers was secured. The growers in each municipality were then interviewed at random. Their answers to prepared questionnaires were recorded. More than three hundred growers were approached and interviewed, but only 196 of these gave data that were of any importance for the study. Merchants who deal in buying and selling lanzones, as well as town officials, were also interviewed and their answers recorded on the questionnaires prepared for this purpose. Prices of lanzones in Manila were secured from the Bureau of Commerce. The figures from the Bureau of Commerce represent the daily retail prices of the fruit in the city of Manila for the season under study, 1938.

RESULTS AND DISCUSSIONS

Glossary of trade terms used in the marketing of lanzones

Local buyer. A person who lives in a municipality and buys from growers on his own account. He does not move from one town to another.

Traveling buyer. A man who is located in a shipping section or town for the harvesting season and then moves on to the next shipping point or town where the harvesting of the product is going on. This buyer is usually connected with the city dealer.

Lanzones dealer. A middleman who receives lanzones on consignment from growers, commission agents, traveling buyers, and local buyers. He then ships the fruit to various merchants, retail stores, hotels, and restaurants.

Commission agent. A middleman who buys lanzones from growers not on his own account but receives a certain percentage of the selling price of the product as his compensation.

Town merchant. A person who buys and sells lanzones in his own town or buys the fruit in his own town and sells it in another town, or he buys the fruit from another town and sells it in his own. He usually has a store in his own town.

Terms of sale

Sale for cash. The results of the survey reveal that 40, or 20.4 per cent, of the total number of growers surveyed sold their lanzones for cash. These growers sold 5,281 *kaings*, or 45.3 per cent, of the total number of *kaings* covered by the survey, amounting to 11,645 *kaings* (table 5). Among the 40 growers who sold for cash, the largest estate was the Hacienda Calauan, which sold 4,065 *kaings* of lanzones by this method. The other 39 growers sold only 1,216 *kaings*, or an average of 31.18 *kaings* per grower.

Sale by contract. This was the most common method of sale of lanzones produced in the province of Laguna, it being the most common method found in all the towns surveyed. There were 148, or 75.5 per cent, of the 196 growers surveyed who sold their lanzones by contract. The amount of fruit sold by these 148 growers was 6,125 *kaings*, or an average of 41.37 *kaings* per grower. This total number of *kaings* sold by contract constituted 52.6 per cent of the total quantity of lanzones covered by the survey (table 5).

Sale by contract is said to be prevalent in the towns of Laguna where the lanzones are produced on a large scale, especially in the towns of San Pablo, Paete, Nagcarlan, and Pakil.

There are two types of agreement under the contract method of sale of lanzones in Laguna. The first type is a contract which merely assures the buyer that the grower will sell his lanzones at harvest to no other dealer. The price to be paid for the lanzones purchased under this type of agreement will be the current market price in the locality at the time of the disposal of the fruit. Under this type of agreement, both the buyer and the seller assume practically no risks.

The second type of agreement is a contract in which the buyer, either just before the fruit is ready for harvesting or during the flowering season, agrees to pay a certain price for the lanzones produced. This type of agreement presupposes a great skill in the art of estimating the quantity of lanzones on a bearing tree or the quantity of the fruit that will be harvested from a tree that has just finished flowering. Both the grower and the buyer are said to be keen in making such estimates. This type of agreement throws the burden of risk-taking on the shoulders of the buyer, because after the agreement is concluded, he assumes the responsibility of taking care of the bearing or flowering trees until the fruit is harvested. Another characteristic of this type of agreement is that it is speculative. It assures the grower of an income from his trees, because once he has entered into an agreement with a buyer, he immediately receives the whole or a part of the contract price for the estimated production of his lanzones plantation. However, if he is less skillful than the buyer in estimating the quantity of fruit on a bearing tree or the probable harvest from a blossoming tree, he loses a certain amount from the bargain. But, if weather conditions become bad after the contract has been entered into between the parties and the harvest from the trees falls short of the estimates, the buyer in such a case loses in the transaction.

The work of estimating the amount of lanzones on a bearing tree or the probable quantity of the fruit to be harvested from a tree in blossom is very interesting. Suppose a grower has 100 trees which are either bearing or have just finished flowering. The grower and the prospective buyer make a careful inspection of the trees and each makes his own estimate of their yields. For example, all trees which show signs of yielding 6 *kaings* will be under group *A*, all those yielding 5 *kaings* will fall under group *B*, those yielding 4 *kaings* will be under group *C*, and so on until every one of the 100 trees has been assigned to a group. Of course, in this work, the grower and the prospective buyer make their estimates and grouping of the trees independently. On the basis of these estimates, they begin to bargain with each other. After they have agreed on a price and other terms, the agreement is concluded. The buyer then either pays for the whole estimated quantity of lanzones covered in the agreement or advances only a part of the payment, the balance of the purchase price to be paid any time between the signing of the agreement and the harvesting of the fruit. After the conclusion of the agreement, the buyer begins to assume the responsibility of taking care of the bearing or flowering trees until the fruit is harvested by him.

Under the sale by contract, the grower reserves the right to set aside a portion of the production of his plantation for his and his family's consumption. This may be so many *kaings* or so many bearing trees, depending on the terms of the agreement.

The agreement between the grower and the buyer under the contract method of sale may be written or verbal. The contract is written when the grower does not know the buyer well enough to have developed confidence in him and it is verbal when both the grower and the buyer have had long business dealings with each other.

Sale by other methods. There were 8 growers, or 4.1 per cent of the 196 growers surveyed, who sold their lanzones before the flowering season. These growers sold 87 *kaings,* or 0.8 per cent of the total amount of lanzones covered by the survey. They borrowed money from local buyers with a promise to pay back such loans in lanzones during the harvest season of the crop. The local buyers usually collected a *kaing* of lanzones for every ₱2.00 or ₱2.50 advanced to such growers. It is seen that this method of sale was disadvantageous to the growers because they received prices for their lanzones which were much lower than the current market prices of the product. This method of sale was found only in the towns of Paete, Pakil, Loñgos, and Siniloan.

Methods of marketing

Direct method. There were two direct ways of marketing the lanzones produced in the province of Laguna. These were (*a*) sale direct to consumers at the public markets, and (*b*) sale by growers direct to consumers at their homes. There were 34 growers, or 13.9 per cent of the total covered by the survey, who sold their lanzones at the municipal markets. These growers sold 156 *kaings,* or 1.3 per cent of the total number of *kaings* of lanzones covered by the study (table 5). It cannot be stated definitely, however, that all of these 156 *kaings* were bought from the growers at the public markets by final consumers, because some of those who purchased the fruit might have been retailers, local buyers, or traveling buyers.

There were 14 growers, or 5.7 per cent of the total surveyed, who sold their lanzones directly to consumers at their homes. These growers sold 41 *kaings,* or 0.4 per cent of the total quantity of lanzones covered by the survey, by this direct method of marketing (table 5).

Indirect method. This method consists of sales to local buyers, to traveling buyers who came to the grower's place, direct sale to retailers by the growers, and sale to other merchants. There were 148 growers, or 60.4 per cent of the total, who sold their lanzones to local buyers. These growers sold 6,646 *kaings,* or 57.0 per cent of the total, by this method. There were 14 growers, or 5.7 per cent of the total, who sold their lanzones to traveling buyers. These growers sold 129 *kaings*, or 1.1 per cent of the total, by this method. There were 28 growers, or 11.4 per cent, who sold their lanzones directly to retailers. These growers sold 192 *kaings,* or 1.6 per cent of the total by this method. There were 7 growers, or 2.9 per cent, who sold their lanzones to other merchants. The "other merchants" in this case refers to buyers, town merchants and Manila dealers, who paid for the fruit at current market prices. Although the number of these growers is relatively small, nevertheless, the amount of lanzones they sold was large, they having disposed of 4,329 *kaings*, or 37.3 per cent of the total quantity of lanzones covered by this survey (table 5).

It is seen that 11,296 *kaings,* or 97.0 per cent of the total amount of lanzones covered by the survey, were sold by the indirect methods of marketing mentioned above. This means that middlemen play a very important part in the marketing of this product.

The results of the survey showed that the bulk of lanzones produced in Laguna passed through the hands of from one to four middlemen on its journey from the grower to the final consumer.

Means of transportation

Man power. On plantations located near the provincial highways, such as those in San Pablo, man power is the most common means of transportation employed in hauling lanzones to the road or nearest shipping point or town. The lanzones are carried in *kaings* on the shoulders of men.

Animal driven vehicles and animal power. Carretelas or carromatas, sledges, and carts drawn by horses or carabaos, as well as baskets on the backs of carabaos, were employed in hauling lanzones. In rural districts as Palasan and Patimbao of the town of Santa Cruz where there are level third class barrio roads, carretelas or carromatas, sledges, and carts were used in hauling the fruit in *kaings* from plantations to the towns or shipping points. Automobiles or trucks could not be used in these places because of the rugged condition of the muddy roads. In some barrios in the towns of Magdalena and Nagcarlan, sledges were used in hauling the lanzones to the towns or shipping points. In the municipality of Siniloan, some of the lanzones plantations are very far from the town and the trails are rugged and muddy during the harvest season. Lanzones on such plantations are carried on the backs of carabaos to the town or shipping point.

It is obvious, of course, that where there are such poor roads and long distances between the plantations and the towns or shipping points, the cost of transporting the fruit is relatively high.

Trucks or automobiles. Although the exact amount is not known, most of the lanzones produced in Laguna are carried in trucks from the different towns to Manila and other places on the island of Luzon. The Director of the Bureau of Commerce corroborated this statement when he said, in answer to an inquiry from the writers: "We are not able to give you data on the quantity of lanzones arriving in Manila from the province of Laguna either daily or weekly, because most of the fruit brought to the city from that province is carried by trucks."

Trucks are said to be more convenient than the railroad in transporting lanzones to distant places. The use of trucks avoids double loading and unloading, hence, the claim that transporting by trucks costs less than by railroad. Once the fruit is loaded on trucks at the local shipping points or producing towns, it can be carried directly to the markets, hotels, restaurants, or retail stores in Manila.

Water transportation. Before the bus companies were in operation in the province of Laguna, the steamboats of the Yangco Steamship Company carried the lanzones produced in the towns of Siniloan, Pakil, Paete, and Loñgos to Manila. After the construction of good roads between all towns in Laguna and Manila and other towns in other provinces had been completed, however, the buses took the place of the Yangco steamboats and the railroads.

Cost of marketing

In general, marketing costs include handling at local points, transportation, taxes, handling by various classes of dealers including repacking, storage, damage, and delivery to retailers, and handling through retail stores, including delivery to consumers.

In this survey, the itemizing of the cost of marketing was found to be difficult as the growers and dealers interviewed did not keep any records of expenses incurred in the different processes of marketing. The prices received by the growers from the dealers, however, and those paid by the consumers are available. Hence, the cost of marketing as discussed in this work is represented by the difference between the price received by the growers and that paid by the consumers. The price paid by the consumers, which in this case is the retail price of the lanzones in Manila reported by the Bureau of Commerce, is considered as 100 per cent. The difference between this retail price and that received by the grower is the margin or cost of marketing. This marketing cost, as well as the price received by the grower, may be expressed as a certain percentage of the retail price. In this connection, Weld (1920) states that it is convenient to consider the cost of marketing from the viewpoint of the producer by expressing the amount that he received as a percentage of the final price.

Price received by growers.[4] Table 6 shows the weekly price per *kaing* of lanzones received by growers who sold their product for cash at the current market price in the towns surveyed in the province of Laguna. Table 7 shows the daily retail price of lanzones in the city of Manila. These two tables indicate that the price of lanzones is lowest during the middle of August (the average per *kaing* during the week ending August 21, 1938, being ₱4.38), when the peak of production is reached, and it is highest during the beginning of the season early in July (being ₱15.00 per *kaing* during the week ending July 10, 1938) and toward the end of the season during the first half of November (being ₱12.50 per *kaing* during the week ending November 20, 1938). Chart 1 shows the trend of the price of lanzones in Laguna and Manila during the season.

Table 9 shows the average price received by lanzones growers of Laguna, who sold their fruit by contract. The average price per *kaing* received by growers who sold their lanzones by contract ranged from ₱3.03 (average price received by such growers in the town of San Pablo) to ₱5.90 (average price received by such growers in the town of Siniloan). The average price received by all such growers covered by the survey was ₱4.40 per *kaing*. The average price per *kaing* of lanzones received by such growers in each of the towns surveyed was as follows: those in Lilio, ₱3.85; those in Loñgos, ₱4.33; those in Magdalena, ₱3.66; those in Majayjay, ₱3.59; those in Nagcarlan, ₱4.27; those in Paete, ₱4.86; those in Pakil, ₱5.15; those in San Pablo, ₱3.03; those in Santa Cruz ₱5.39; and those in Siniloan, ₱5.90. None of the growers interviewed in Calauan and Rizal sold their lanzones during that season by contract. If we consider the average retail price of lanzones in Manila as the final consumer's price, which was ₱13.28 per *kaing* for the season, the growers who sold their lanzones by contract received the following proportion of this consumer's price: those surveyed in Lilio received only 29.0 per cent of the consumer's price; those in Loñgos, 32.61 per cent; those in Magdalena, 27.57 per cent; those in Nagcarlan, 32.16 per cent; those in Majayjay, 27.04 per cent; those in Paete, 36.60 per cent; those in Pakil, 38.78 per cent; those in San Pablo, 22.82 per cent; those in Santa Cruz, 40.59 per cent; and those in Siniloan, 44.43 per cent. The average proportion of this consumer's price received by all such growers surveyed was 33.13 per cent.

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[4] The price received by growers is the price at the plantation. It does not include the cost of hauling the fruits from the plantation to the local shipping point, as is usually understood when the farmer's price is discussed. This was done because it was found convenient to explain the cases of growers in the towns of Pakil and Siniloan, by considering the price received by growers as such.

In table 9 is also shown the average price per *kaing* received by growers of lanzones who sold their crop not by contract. The average price per *kaing* received by such growers in each of the towns covered by the survey ranged from ₱4.15 (average price per *kaing* received by such growers in Magdalena) to ₱6.34 (average price per *kaing* received by such growers in Paete). The average price received by all such growers covered by the survey was ₱5.20 per *kaing*.—In determining this average, the price received by the Hacienda Calauan was not included in the computation, because this large estate, with its own trucks, was the only grower who delivered the product directly to the dealers in Manila. Consequently, the price this estate received (₱7.74 per *kaing*) was exceptionally high.

In the different towns surveyed, the average price received by growers who sold their lanzones not by contract was as follows: those in Lilio, ₱5.20 per *kaing;* those in Loñgos, ₱5.36; those in Magdalena, ₱4.15; those in Majayjay, ₱4.48; those in Nagcarlan, ₱4.75; those in Paete, ₱6.34; those in Pakil, ₱5.01; those in Rizal, ₱5.86; those in San Pablo, ₱4.80; those in Santa Cruz, ₱6.01; and those in Siniloan, ₱5.22. The price received by the Hacienda Calauan has already been mentioned above.

In all the towns surveyed, it is seen that, with the exception of the growers in Pakil and Siniloan, the average price received by growers who sold their lanzones not by contract was higher than that received by growers who sold their product of the same season by contract. This is, of course, expected because of the risks assumed and expenses incurred by the buyer. In Siniloan the average price received by growers who sold their lanzones by contract was higher than that received by those who sold the product not by contract because of the exceptionally high cost of hauling the product from the plantations to the town or shipping point. This exceptionally high cost of hauling made the cost of marketing, which was deducted from the price received by growers who sold their lanzones not by contract, unusually high (table 8). Hence, the price received by such growers was lower than that received by the growers who sold their fruit by contract. There was no apparent explanation for the existence of the same condition in Pakil as that found in Siniloan. The only possible explanation for the fact that in that town the growers who sold their lanzones by contract received higher prices than those received by growers who sold their product not by contract is that the growers in the town might have sold their crop to contractors who paid for the product on the basis of the estimated harvest from the plantation or a given number of trees. Under this condition, the price received per *kaing* by the growers was high or low, depending on the amount of the actual harvest from the contracted trees. Moreover, the growers might have been more experienced in making the estimates of the production of lanzones trees than the buyers, or weather conditions might have been unfavorable to the buyers, so that after they had contracted the fruit, the effect of bad weather reduced their estimated harvest.

If the average retail price in Manila is assumed to be the final consumer's price for the product (₱13.28 per *kaing*), the growers who sold their crop of lanzones not by contract received only 39.16 per cent of this consumer's price. The proportion of this consumer's price received by growers who sold their crop not by contract was as follows: those in Lilio, 39.16 per cent; those in Loñgos, 40.37 per cent; those in Magdalena, 31.16 per cent; those in Majayjay, 33.74 per cent; those in Nagcarlan, 35.77 per cent; those in Paete, 47.74 per cent; those in Pakil, 37.73 per cent; those in Rizal, 44.13 per cent; those in San Pablo, 36.15 per cent; those in Santa Cruz, 45.26 per cent; and those in Siniloan, 39.31 per cent.

Middlemen's margin. The middlemen's margin consists of the cost of marketing and the profit of middlemen participating in the marketing of a given product. Clark and Weld (1932), however, referred to this middlemen's margin as the cost of marketing. In this study, Clark and Weld's meaning has been adopted for the term "middlemen's margin."

Table 9 shows the middlemen's margin per *kaing* of lanzones in the different towns surveyed in the province of Laguna. If the retail price in Manila is assumed to be the final consumer's price (₱13.28 per *kaing*), the middlemen who purchased lanzones by contract had a margin per *kaing* on the lanzones they bought as follows: those who bought the fruit by contract in Lilio, ₱9.43, or 71.00 per cent; those in Loñgos, ₱8.95, or 67.39 per cent; those in Magdalena, ₱9.62, or 72.43 per cent; those in Majayjay, ₱9.69, or 72.96 per cent; those in Nagcarlan, ₱9.01, or 67.84 per cent; those in Paete, ₱8.52, or 63.40 per cent; those in Pakil, ₱8.13, or 61.22 per cent; those in San Pablo, ₱10.25, or 77.18 per cent; those in Santa Cruz, ₱7.89, or 59.41 per cent; and those in Siniloan, ₱7.38, or 55.57 per cent. The average margin of all middlemen who bought lanzones by contract was ₱8.88, or 66.87 per cent.

Middlemen who purchased lanzones of the same season not by contract had an average margin for the whole survey of ₱8.08 per *kaing*, or 60.84 per cent of the consumer's price. The average margin of these middlemen in the different towns covered by the survey was as follows: those who bought lanzones not by contract in Calauan, ₱5.54, or 40.71 per cent; those in Lilio, ₱8.08, or 60.84 per cent; those in Loñgos, ₱7.92, or 59.63 per cent; those in Magdalena, ₱9.13, or 68.75 per cent; those in Majayjay, ₱8.80, or 66.26 per cent; those in Nagcarlan, ₱8.53, or 64.23 per cent; those in Paete, ₱6.94, or 52.26 per cent; those in Rizal, ₱7.42, or 55.87 per cent; those in Pakil, ₱8.27, or 62.27 per cent; those in San Pablo, ₱8.48, or 63.85 per cent; those in Santa Cruz, ₱7.27, or 54.74 per cent; and those in Siniloan, ₱8.06, or 60.69 per cent. All the above figures refer to middlemen's margin per *kaing*.

The above margin of middlemen engaged in the marketing of lanzones produced in the province of Laguna is large. Although a wide margin for middlemen is a general characteristic of the marketing of perishable farm products, such as fruits, eggs, etc., nevertheless, the middlemen's margin as shown by this survey of the marketing of lanzones in Laguna is exceptionally large. This large margin indicates that there must be, in the marketing of this fruit, some middlemen's functions which are duplicated and that the actual number of middlemen through whose hands the product passes on its journey from the producer to the consumer may be large. If such a condition exists, then there is room for improving the marketing of this product in order to increase the growers' share of the consumer's price. One improvement that might make possible a more direct distribution of the fruit from the producers to the consumers is the organization of co-operative marketing associations by the lanzones growers. Such co-operative marketing associations could sell the fruit directly to either dealers in Manila or other large market centers and to hotels, restaurants, retail stores, and the public markets. In this way, the price received by growers would be increased, because the remuneration required by middlemen whose services are no longer necessary, inasmuch as such services are integrated in the co-operative associations, is no longer deducted from the grower's share of the consumer's price. The advantage of a more direct distribution to retail dealers has already been proved by the Hacienda Calauan. Because this large estate produced sufficient lanzones to make it possible for it to transport the fruit economically to Manila on its own trucks, the estate was able to receive the highest average price per *kaing* of lanzones among the producers surveyed for the 1938 crop. But only the large producers can afford to transport their lanzones to Manila. The small producers can not do this economically without co-operative marketing associations so that they can pool their product for economical distribution. Moreover, perishable products, especially fruit, have proved themselves to be successfully handled by co-operative marketing organizations elsewhere.

Other possible improvements would be canning of the fruit and storing it at temperatures of from 13 to 15.5 degrees C. which have been found by San Pedro (1936) to be ideal; this would remove the glut in the market during the flush of the season and serve to stabilize the price of the product at a fairly high level.

An attempt was made to study the various items involved in the marketing cost borne by the growers. Table 8 shows the costs, borne by the growers who did not sell their fruit by contract, of marketing a *kaing* of lanzones. According to this table, the total average cost of marketing a *kaing* of lanzones in each of the towns surveyed was fairly uniform. The total average cost of marketing amounted to ₱0.86 per *kaing* for the whole survey, of which ₱0.21 was cost of protecting the fruit on the trees from bats; ₱0.24, the cost of picking; ₱0.01, packing; ₱0.15, hauling; and ₱0.25, packaging. These costs, of course, were deducted from the selling price of the fruit and the remainder was reported in this study as the price received by the growers who did not sell their lanzones by contract.

Financing marketing operations

From advances of middlemen. The burden of financing the marketing of lanzones produced in the province of Laguna is borne by the middlemen. Since the bulk of the season's crop is sold by contract, the buyers assume the burden of defraying the expenses of caring for flowering trees until harvest time, of harvesting, and of other processes that are involved in preparing the fruit for market. In most cases, the local and traveling buyers who bought lanzones by contract advanced either the whole payment or only a part of the contract price, the remaining unpaid amount to be paid any time before the crop was harvested. There were cases where some local merchants, who wanted to be assured of their supply, in the large towns of the province of Laguna, such as San Pablo, Pagsanjan, and Santa Cruz, advanced money to small growers long before the harvest season. The loans were to be paid in lanzones at harvest time; the price of the lanzones to be used as repayment for such loans would be the current market price at that place.

From personal savings of growers. With the exception of the Hacienda Calauan, where expenses in connection with the marketing of the 1938 lanzones crop were defrayed from the funds of the estate, none of the other 195 growers surveyed defrayed the expenses of marketing their fruit from their personal savings.

SUMMARY AND CONCLUSIONS

The following summary and conclusions may be derived from the results of the survey:

1. The marketing season of lanzones in the province of Laguna is short, lasting for about four to five months (July to November). The greater part of the fruit during the season goes to the market within less than one month. This condition gives rise to the very wide fluctuation in the price of the fruit during the season, which is to the disadvantage of the growers. The price of lanzones is very high at the beginning and toward the end of the season when the supply of the product is scarce, and is very low about the middle of the season during the second half of August when the market is glutted with the fruit. For instance, the average price per *kaing* of lanzones in Laguna during the week ending on July 10 was ₱15.00; this figure dropped to ₱4.38 during the week ending August 21, then, increased to ₱12.50 during the week ending November 20. There is, therefore,

a difference of from ₱8.12 to ₱10.62 between the highest and the lowest price of a *kaing* of lanzones during the marketing season of the fruit in Laguna.

This wide fluctuation of the price of the fruit is to the disadvantage of the growers, especially the small growers who seldom sell their product by contract. Since a large majority of the lanzones producers are small growers, a great number of them are affected by the low price of the season when every grower has some lanzones to sell. Only those few growers who have trees bearing early or late in the season benefit from the high prices. The marketing season of lanzones may be lengthened in order to enable the growers to keep the price of the product at a fairly high level throughout the season by either furnishing them with storage facilities or removing some of the excess fruit during the flush of the season from the market and preserving it by canning. The growers themselves might furnish the storing facilities if they were organized. The canning of the fruit might be done by the National Food Products Corporation, which is now canning fish and has announced its plan to can fruit and vegetables in the near future.

2. The growers of lanzones in Laguna received for their 1938 crop an average price of ₱4.40 per *kaing* when they sold the fruit by contract. This amount was only 33.13 per cent of the consumer's price of ₱13.28. When they sold their lanzones not by contract, the growers received an average price of ₱5.20 a *kaing*, which was higher than that received by the growers who sold their crop by contract and was 39.16 per cent of the consumer's price.

3. The middlemen's margin in the marketing of lanzones in Laguna is very large, which means that the cost of marketing this product is very high. The margin per *kaing* of middlemen who bought lanzones in Laguna by contract was ₱8.88, or 66.87 per cent. The middlemen who purchased lanzones in the province not by contract had a margin of ₱8.08 per *kaing*, or 60.84 per cent.

A fairly large middlemen's margin is a characteristic of the marketing of highly perishable farm products, such as fruits and vegetables, but the middlemen's margin shown in the survey is exceptionally large, indicating that there are either many inefficient hands through which the product passes on its journey from the grower to the final consumer or there are a number of middlemen's functions which are unnecessarily duplicated in the process of marketing it.

This large middlemen's margin may be reduced in order to increase the grower's share of the consumer's price if the growers can sell their product directly to the dealers in Manila and other large market centers, as well as to the consumers. This direct marketing may be effectively and economically done by co-operative marketing associations owned and controlled by the growers. The services now being rendered by middlemen in the marketing of this product could be integrated in the co-operative marketing associations and any decrease in the cost of marketing as a result of such integration would go to the grower, thereby increasing his share of the consumer's price of the product.

4. The lanzones produced in Laguna passed through the hands of from one to four middlemen on their journey from the grower to the final consumer.

5. The outlets for lanzones produced in Laguna in 1938 were the consumers who bought the fruit at the public markets or had it delivered to their homes by the growers, the local buyers who bought the fruit from the growers and sold it at the public markets of the towns of the province, traveling buyers who bought the fruit from the growers and sold it to dealers in Manila and other large markets outside of the province of Laguna, and dealers in Manila who had the fruit delivered to them by the growers. These Manila dealers, in turn, sold the fruit to hotels, restaurants, and consumers in the Manila public markets.

6. Most of the 1938 crop of lanzones in Laguna was sold by the growers by contract, in spite of the fact that growers who sold their product by other methods received higher prices than those who sold by contract. This condition existed perhaps because of the fact that, once the growers had concluded agreements to sell their lanzones by contract to buyers, they relinquished their responsibility of bringing the fruit to maturity, picking it, and preparing it for market. This work was taken over by the buyer who contracted the fruit. There were 148 growers, or 75.5 per cent of the 196 covered by the survey, who sold by contract their 1938 lanzones crop amounting to 6,125 *kaings*, or 41.37 per cent of the total surveyed (11,645 *kaings*).

7. Most of the financing of the marketing of lanzones produced in Laguna in 1938 was borne by the middlemen. This was expected in view of the fact that most of the fruit produced during that season was sold to middlemen by contract.

8. The ability to estimate the harvest from lanzones trees in blossom or already bearing was a prerequisite to bargaining in cases

where the fruit was sold by contract. The growers and the buyers were found to be very skillful in this art. The more experienced the buyers and the growers were in this work, the more nearly accurate their estimates were.

9. Most of the lanzones brought to Manila from the province of Laguna were carried by trucks, which were preferred to the railroad and water transportation facilities because they avoided double loading and unloading, thereby reducing the cost of transporting the product.

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TABLE 1

Leading fruits in the Philippines[a]

NAME OF FRUIT	AREA UNDER CULTIVATION	NUMBER OF TREES	VALUE OF PRODUCTION
	hectares		*pesos*
Banana	102,370.2	70,509,655	12,272,366
Mango	15,300.8	822,628	2,682,108
Lanzones	1,361.4	412,490 [b]	955,650
Papaya	3,980.8	2,653,834	618,802
Pineapple	3,591.4	—	455,081
Pilinut	1,972.4	249,322	296,594
Sweet Orange	1,639.0	372,544	238,100
Mandarin	2,036.0	581,754	282,590
Sugar apple (Atis)	2,691.6	1,365,834	201,384
Pummelo	1,594.0	346,582	183,424
Soursop (Guayabano)	1,000.8	417,522	95,132
Chico	486.4	91,926	93,410
Custard apple (Anonas)	739.6	284,516	70,500

[a] The figures in this table are five-year averages computed from annual figures obtained from the Statistical Handbook of the Philippine Islands for 1932 and from the Philippine Statistical Review, volumes 1-4, 1934-1937. The five-year averages are for the years 1932 to 1936 inclusive.

[b] The number of lanzones trees, five-year averages 1932-1936—for Laguna is 160,164, or 38.76 per cent of the average total number of trees in the Philippines.

TABLE 2

Lanzones production reported by growers interviewed, 1938

MUNICIPALITIES	NUMBER OF PRODUCERS INTERVIEWED	PRODUCTION REPORTED		
		Range	Total	Average per grower
		kaings	*kaings*	*kaings*
Calauan [a]	1	——	4,065	—
Lilio	10	10-70	316	31.6
Loñgos	14	4–248	603	43.1
Magdalena	18	15-60	299	16.6
Majayjay	18	4-130	357	19.8
Nagcarlan	11	25-132	588	53.4
Paete	70	3-130	2,307	32.9
Pakil	13	18-130	851	65.5
Rizal	5	5-15	43	8.6
San Pablo	26	12-470	1,996	76.7
Santa Cruz	5	10–60	138	27.6
Siniloan	5	13-22	82	16.4
Total	196		11,645	

[a] The hacienda of Calauan.

TABLE 3

Municipalities that produced lanzones in Laguna during the season ending June 30, 1937 [a]

MUNICIPALITIES	TREES CULTIVATED	PRODUCTION	TOTAL VALUE
		kaings	*pesos*
Alaminos	4,700	3,840	12,244
Bay	2,600	1,540	8,840
Calauan	8,200	6,840	34,180
Cavinti	2,740	530	4,050
Lilio	5,520	5,180	31,050
Loñgos	7,300	360	2,350
Luisiana	830	120	720
Magdalena	—	—	—
Majayjay	13,000	2,280	2,090
Nagcarlan	19,320	1,530	8,980
Paete	51,420	44,410	268,950
Pakil	22,440	20,390	118,660
Pañgil	7,700	1,300	13,610
Rizal	—	—	—
San Pablo	39,260	37,150	178,540
Santa Cruz	2,520	2,460	14,780
Siniloan	—	—	—
Total	187,550	127,930	699,044

[a] Data taken from the Division of Statistics, Bureau of Commerce, Manila.

TABLE 4

Lanzones production of municipalities surveyed in Laguna, 1938

MUNICIPALITIES	NUMBER OF TREES [a]			APPROXIMATE PRODUCTION OF ASSESSED TREES
	Not assessed [b]	Assessed [c]	Total	
				kaings
Calauan	8,200	6,781	14,981	4,830
Lilio	1,471	7,997	9,468	1,350
Loñgos	6,034	2,996	9,030	1,150
Magdalena	580	1,721	2,301	840
Majayjay	4,690	9,470	14,160	970
Nagcarlan	2,227	17,174	24,401	6,330
Paete	45,924	13,930	69,854	11,480
Pakil	6,772	8,857	15,629	4,430
Rizal	605	2,921	3,526	200
San Pablo	20,084	38,382	58,466	12,800
Santa Cruz	2,159	5,772	7,881	980
Siniloan	4,661	2,068	6,729	850
Total	103,407	118,069	236,426	46,210

[a] Data taken from the provincial treasurer of Laguna.

[b] Not bearing trees.

[c] Bearing trees.

TABLE 5

Showing how the amount of lanzones covered by the survey was disposed of in 1938

TERMS OF SALE OR METHOD OF MARKETING USED	GROWERS INVOLVED		AMOUNT OF LANZONES	
	Number of growers involved	Per cent of total number of growers surveyed	Number of *kaings* involved	Per cent of total number of *kaings* covered by the survey
Terms of sale:				
Sale for cash	40	20.4	5,281 [b]	45.3
Sale by contract	148	75.5	6,125	52.6
Sale by other methods	8	4.1	87	0.8
Amount of lanzones used by the growers and their families, of their production reported in the survey	—	—	152	1.3
Total	196	100.0	11,645	100.0
Methods of marketing:				
Sale at public market	34	13.9	156	1.3
Sale to local buyers	148	60.4	6,646	57.0
Sale to buyers who come to grower's place	14	5.7	129	1.1
Direct sale to retailers	28	11.4	192	1.6
Direct sale to consumers at consumer's places	14	5.7	41	0.4
Sale to other merchants	7	2.9	4,329 [b]	37.3
Amount of lanzones used by the growers and their families, of their production reported in the survey	—	—	152	1.3
Total	245 [a]	100.0	11,645	100.0

[a] The total in this case is more than the total for the survey because some of the growers are entered two or more times; that is, some growers sold, for example, at the public market, direct to retailers, and direct to consumers, etc.

[b] These figures appear large because one hacienda in Calauan contributed 4,065 *kaings* in each case.

TABLE 6

Comparative weekly prices per kaing[a] *of lanzones in some of the principal producing localities in Laguna, 1938*

WEEK ENDING		LILIO	LOÑGOS	MAGDALENA	NAGCARLAN	PAETE	PAKIL	RIZAL	SAN PABLO	SANTA CRUZ	SINILOAN	AVERAGE FOR SURVEY
		pesos	*pesos*	*pesos*	*pesos*	*pesos*	*pesos*	*pesos*	*pesos*	*pesos*	*pesos*	*pesos*
July	10	—	15.00	—	—	15.00	15.00	—	—	—	—	15.00
	17	—	13.50	—	—	13.00	13.00	—	—	—	—	13.18
	24	9.50	10.00	—	9.50	10.00	10.00	—	—	—	—	9.80
	31	9.00	10.00	—	9.00	10.00	9.50	—	9.50	—	8.50	9.36
August	7	8.50	9.50	8.30	8.80	9.50	9.50	—	9.00	8.30	8.50	8.88
	14	8.30	9.00	7.20	8.40	9.00	9.00	8.50	7.50	8.20	—	8.44
	21	4.30	5.00	4.20	4.30	5.00	5.00	4.30	3.50	4.20	4.00	4.38
	28	6.30	5.80	6.20	6.40	6.80	6.80	6.30	5.50	6.20	6.00	6.13
September	4	6.50	7.30	6.50	7.00	7.50	7.20	—	7.30	6.50	7.50	7.04
	11	7.50	8.80	—	8.20	9.00	7.80	—	8.50	6.50	7.50	7.98
	18	10.50	11.00	—	11.00	11.00	11.00	—	11.00	—	7.50	10.43
	25	11.30	11.20	—	11.20	11.40	11.30	—	11.40	—	—	11.30
October	2	—	14.00	—	14.00	14.50	14.50	—	14.00	—	—	14.20
	9	—	—	—	—	15.50	—	—	14.50	—	—	15.00
	16	—	—	—	—	15.50	—	—	14.50	—	—	15.00
	23	—	—	—	—	15.00	—	—	13.50	—	—	14.25
	30	—	—	—	—	12.00	—	—	11.00	—	—	11.50
November	6	—	—	—	—	—	—	—	12.00	—	—	12.00
	13	—	—	—	—	—	—	—	12.20	—	—	12.20
	20	—	—	—	—	—	—	—	12.50	—	—	12.50

[a] A *kaing* contains 28 to 30 kilos of lanzones, or from 1500 to 1800 fruits.

TABLE 7

Daily retail quotation of lanzones in Manila, 1938 [a]

DAYS OF THE MONTH	AUGUST			SEPTEMBER			OCTOBER			NOVEMBER			COMPUTED PRICE PER KAING	
	Price per kilo		Computed price per *kaing*	Price per kilo		Computed price per *kaing*	Price per kilo		Computed price per *kaing*	Price per kilo		Computed price per *kaing*		
	Range	Average		Range	Average		Range	Average		Range	Average		Total	Average
	pesos	*pesos*	*pesos*	*pesos*	*pesos*	*pesos*	*pesos*	*pesos*	*pesos*	*pesos*	*pesos*	*pesos*		
1	—	—	—	0.30–0.35	0.325	9.10	0.60–0.65	0.325	17.40	—	—	—	26.50	13.25
2	—	—	—	0.30–0.35	0.325	9.10	—	—	—	0.45–0.50	0.475	13.30	22.40	11.20
3	—	—	—	0.30–0.35	0.325	9.10	0.60–0.65	0.625	17.40	0.45–0.50	0.475	13.30	39.80	13.27
4	—	—	—	—	—	—	0.60–0.65	0.625	17.40	0.45–0.50	0.475	13.30	30.70	15.35
5	—	—	—	0.35–0.40	0.375	10.50	0.60–0.65	0.625	17.40	—	—	—	27.90	13.95
6	—	—	—	0.35–0.40	0.375	10.50	0.60–0.65	0.625	17.40	—	—	—	27.90	13.95
7	—	—	—	0.40–0.45	0.425	11.90	0.55–0.60	0.575	16.10	—	—	—	28.00	14.00
8	—	—	—	0.45–0.50	0.475	13.30	0.50–0.55	0.525	14.70	—	—	—	28.00	14.00
9	—	—	—	0.40–0.45	0.425	11.90	—	—	—	—	—	—	11.90	11.90
10	—	—	—	0.40–0.45	0.425	11.90	0.50–0.55	0.525	14.70	—	—	—	26.60	13.30
11	—	—	—	—	—	—	0.50–0.55	0.525	14.70	—	—	—	14.70	14.70
12	—	—	—	0.40–0.45	0.425	11.90	0.50–0.55	0.525	14.70	—	—	—	26.60	13.30
13	—	—	—	0.40–0.45	0.425	11.90	0.50–0.55	0.525	14.70	—	—	—	26.60	13.30
14	—	—	—	0.40–0.45	0.425	11.90	0.50–0.55	0.525	14.70	—	—	—	26.60	13.30
15	—	—	—	0.40–0.45	0.425	11.90	0.50–0.55	0.525	14.70	—	—	—	26.60	13.30
16	—	—	—	0.45–0.50	0.475	13.30	—	—	—	—	—	—	13.30	13.30
17	—	—	—	0.45–0.50	0.475	13.30	0.50–0.55	0.525	14.70	—	—	—	28.00	14.00
18	—	—	—	—	—	—	0.50–0.55	0.525	14.70	—	—	—	14.70	14.70
19	0.35–0.45	0.400	11.20	0.45–0.50	0.475	13.30	0.50–0.55	0.525	14.70	—	—	—	39.20	13.07
20	0.30–0.35	0.350	9.80	0.45–0.50	0.475	13.30	0.50–0.55	0.525	14.70	—	—	—	37.80	12.00
21	—	—	—	0.45–0.50	0.475	13.30	0.50–0.55	0.525	14.70	—	—	—	28.00	14.00
22	0.30–0.35	0.325	9.10	0.45–0.50	0.475	13.30	0.50–0.55	0.525	14.70	—	—	—	37.10	12.37
23	0.30–0.35	0.325	9.10	0.45–0.50	0.475	13.30	—	—	—	—	—	—	22.40	11.20
24	0.30–0.35	0.325	9.10	0.45–0.50	0.475	13.30	0.50–0.55	0.525	14.70	—	—	—	37.10	12.37
25	0.30–0.35	0.325	9.10	—	—	—	0.50–0.55	0.525	14.70	—	—	—	23.80	11.90
26	0.30–0.35	0.325	9.10	0.45–0.50	0.475	13.30	0.50–0.55	0.525	14.70	—	—	—	37.10	12.33
27	0.30–0.35	0.325	9.10	0.50–0.55	0.525	14.70	0.50–0.55	0.525	14.70	—	—	—	38.50	12.83
28	—	—	—	0.50–0.55	0.525	14.70	0.45–0.50	0.475	13.30	—	—	—	28.00	14.00
29	0.30–0.35	0.325	9.10	0.55–0.60	0.575	16.10	0.45–0.50	0.475	13.30	—	—	—	38.50	12.83
30	0.30–0.35	0.325	9.10	0.60–0.65	0.625	17.40	—	—	—	—	—	—	26.50	13.25
31	0.30–0.35	0.325	9.10	—	—	—	0.45–0.50	0.475	13.30	—	—	—	22.40	11.20
Average	0.305–0.363	0.334	9.35	0.422–0.492	0.467	13.32	0.515–0.565	0.540	15.12	0.450–0.500	0.475	13.30	13.28	13.28

[a] The data were furnished by the Bureau of Commerce, Manila.

[b] Using 28 kilos as the weight of one *kaing* of lanzones.

TABLE 8

Comparative cost of marketing per kaing of lanzones borne by Laguna growers who did not sell fruit by contract, 1938

MUNICIPALITIES	ITEMS OF COST					
	Care against bats	Picking	Packing	Hauling	Packaging	Total
	pesos	*pesos*	*pesos*	*pesos*	*pesos*	*pesos*
Calauan	0.122	0.150	.010	0.100	0.250	0.407
Lilio	—	0.321	.010	0.150	0.250	0.506
Loñgos	0.200	0.228	.010	0.100	0.250	0.563
Magdalena	0.250	0.266	.010	0.100	0.250	0.651
Majayjay	0.183	0.200	.010	0.100	0.250	0.518
Nagcarlan	0.236	0.233	.010	0.133	0.250	0.637
Paete	0.218	0.216	.010	0.109	0.250	0.578
Pakil	0.250	0.200	.010	0.100	0.250	0.585
Rizal	—	0.325	.010	0.100	0.250	0.460
San Pablo	0.219	0.155	.010	0.100	0.250	0.509
Santa Cruz	—	0.300	.010	0.075	0.250	0.410
Siniloan	0.191	0.277	.010	0.655	0.250	1.158
Total	1.869	2.871	.120	1.822	0.300	6.982
Average	0.21	0.24	.010	0.150	0.250	0.86

TABLE 9

Middlemen's margin and proportion of consumer's price received by growers of lanzones in Laguna for their 1938 crop

MUNICIPALITIES SURVEYED	AVERAGE RETAIL PRICE PER *kaing* IN MANILA (100%)	AVERAGE PRICE PER *kaing* RECEIVED BY GROWERS WHO				MIDDLEMEN'S MARGIN PER *kaing* OF LANZONES PURCHASED			
		sold by contract		sold not by contract		By contract		Not by contract	
		Amount	Per cent of consumer's price	Amount	Per cent of consumer's price	Amount	Per cent of consumer's price	Amount	Per cent of consumer's price
	pesos	*pesos*		*pesos*		*pesos*		*pesos*	
Calauan	13.28	—	—	7.74	58.29	—	—	5.54	41.71
Lilio	13.28	3.85	29.00	5.20	39.16	9.43	71.00	8.08	60.84
Loñgos	13.28	4.33	32.61	5.36	40.37	8.95	67.39	7.92	66.76
Magdalena	13.28	3.66	27.57	4.15	31.16	9.62	78.43	9.13	59.63
Majayjay	13.28	3.59	27.04	4.48	33.74	9.69	72.96	8.80	68.75
Nagcarlan	13.28	4.27	32.16	4.75	35.77	9.01	67.84	8.53	64.23
Paete	13.28	4.86	36.60	6.34	47.74	8.42	63.40	6.94	52.26
Pakil	13.28	5.15	38.78	5.01	37.73	8.13	61.22	8.27	62.27
Rizal	13.28	—	—	5.86	44.13	—	—	7.42	55.87
San Pablo	13.28	3.03	22.82	4.80	36.15	10.25	77.18	8.48	63.85
Santa Cruz	13.28	5.39	40.59	6.01	45.26	7.89	59.41	7.27	54.74
Siniloan	13.28	5.90	44.43	5.22	39.31	7.38	55.57	8.06	60.69
Average for survey	13.28	4.40	33.13	5.20[a]	31.16	8.88	66.87	8.08	60.84

[a] This average does not include the price received by the Hacienda Calauan (₱7.74 per *kaing*.)

THE INFLUENCE OF DIFFERENT SOIL MEDIA ON THE RATE OF GROWTH OF CERTAIN KINDS OF FRUIT PLANTS [1]

XOM RAKTAKANISHTA

The importance of using healthy, vigorous seedlings for planting cannot be overemphasized, especially in the culture of perennial crops.

Optimum climatic conditions, good soil, an effective protection against plant enemies, and judicious care are necessary to grow plants successfully. In this study, only the influence of soil media was taken up.

Available literature shows that no work has been done on the influence of different soil media on the rate of growth of the fruit plants used in this study.

The main object of the work was to determine the influence of certain types of soil on the rate of growth of avocado, lanzones, and star apple seedlings under the conditions in the nursery of the Pomology Division.

The work was conducted in the Pomology nursery, Department of Agronomy, College of Agriculture, from December, 1936, to September, 1938.

MATERIALS AND METHODS

Equipment

a. Kinds of fruit plants.—Three kinds of seedlings were used in the experiment: avocado, *Persea americana* Mill., lanzones, *Lansium domesticum* Correa, and star apple, *Chrysophyllum cainito* Linn.

Because of the large number of plants used, it was not possible to utilize containers of the same size for all the plants; but for each kind, only one size was used.

For avocado seedlings, No. 6 pots, each measuring 20 centimeters high, 25 centimeters in diameter at the mouth, and 19 centimeters in diameter at the bottom, were used. The star apple seedlings were planted in No. 5 pots, each measuring 19 centimeters high, 22 centimeters wide, and 14 centimeters at the bottom. The lanzones seedlings were placed in No. 3 pots measuring 13 centimeters high, 15 centimeters wide, and 10 centimeters at the bottom.

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[1] Experiment Station contribution No. 1335. Prepared in the Department of Agronomy under the direction of Associate Professor L. G. Gonzalez.

b. Different soil media.—Six different kinds of soil media were used:

Clay loam
River sand
¼ clay loam and ¾ river sand
½ clay loam and ½ river sand
¾ clay loam and ¼ river sand
Compost

The garden soil characterized as clay loam in texture was obtained from the vegetable garden back of the nursery. It was prepared by digging the surface soil to a depth of about one-half meter and pulverizing and sifting it through a one-eighth inch mesh wire sieve. A sufficient amount was prepared and deposited in concrete compartments in the nursery to serve as stock.

River sand was secured from the San Cristobal river bed, Calamba, Laguna, and sifted through the same sieve, after which it was stored in one of the concrete compartments in the nursery.

The different mixtures were prepared by combining the different amounts of clay loam and river sand in the proportion desired and by mixing them thoroughly. Enough was prepared to last throughout the experiment.

The compost had been prepared about two years before by piling soybean vines in an open ground pit about four meters square and two and one-half meters deep. At the time of the experiment, the material was well decayed and a fine compost was obtained after sieving.

The miscellaneous nursery tools and equipment used in the experiments were spades, kerosene cans, balance, caliper, and foot-rule.

Procedure

a. Physical analysis of soils.—With the help of Mr. Jesus P. Mamisao of the Department of Soils, the different soil media were analyzed for some of their physical constituents. Ten grams of each kind of soil were weighed in duplicate.

The organic matter was decomposed by using 6 per cent hydrogen peroxide. After the decomposition, the excess peroxide was boiled off to dryness. The samples were washed with distilled water, evaporated to dryness on a steam bath, and dried in an oven at 105° C for 16 hours. After cooling in a desiccator, the samples were weighed to determine the weight lost, which represented the organic matter.

To the organic matter-free sample was added a known amount of distilled water, and the mixture was transferred to a 250 cc. nursing bottle. Ten cubic centimeters of 0.5 N. sodium oxalate were added and the volume of the mixture was made up to 150 cc. by adding more distilled water. The contents were shaken for one night by an electrically-run reciprocal shaker.

The clay and colloid were determined by sedimentation and the pipette method. The sand and remaining silt were washed and dried at 150° C for four hours; they were then cooled in a desiccator, weighed, separated by a nest of graded sieves into size classes, and the percentage weight of each class was determined.

b. Chemical analysis of the soil.—The determination of total nitrogen (N), phosphoric acid (P_2O_5), and potash (K_2O) of the different soil media was made in the Department of Agricultural Chemistry by Mr. L. A. Ynalvez. He used the standard method of analysis recommended by the Association of Official Agricultural Chemists (1930).

c. Germinating the seeds and transplanting the seedlings.—The seeds of star apple were collected from a single tree in the orchard of the Agronomy Department. The lanzones seeds were obtained from a basket of fruit claimed to be from Paete, Laguna. The avocado seeds were gathered from fruit harvested from different trees in the College orchard. The seeds were planted in seed boxes and allowed to germinate and grow for about six months.

In selecting the seedlings for study, care was taken to include only normal looking ones and as much as possible those that were similar in external characteristics, such as size, color, and apparent vigor.

The seedlings were removed from the seed box and the roots carefully washed with water to remove as much soil as possible without injuring them. After the seedlings were weighed, they were planted in their respective pots containing the different soil media. The pots were properly numbered, twenty of each kind for each soil medium.

The newly potted plants were kept in the shade inside the nursery for about one month, then transferred outside in diffused sunlight, in the shade of bamboo, and left there until the end of the experiment.

The plants were measured every two weeks for increase in girth and height. The base of the stem was marked with India ink, and a caliper was used for measuring the girth. The height was measured from a base mark to the tip of the plants. Recorded observations were kept of the condition including general appearance and vigor of the plants.

At the close of the experiment, the plants were carefully washed and weighed individually to determine increase in weight during the time of the experiment.

RESULTS

The results of the physical analysis of the different soil media are presented in table 1, and those of the chemical analysis, in table 2.

The average bi-weekly increments in height and increase in girth and total gains in weight of avocado, lanzones, and star apple are presented in table 3.

DISCUSSION OF RESULTS

Grouping the soils on the basis of their mechanical analysis

The different kinds of soil used in this experiment may be grouped on the basis of their mechanical compositions (table 1), with the work of Davis and Bennett (1927) used as the standard. According to this, the medium referred to as "clay loam" should be "clay" and "river sand", "sand". "Compost" falls within the group "clay", but to differentiate it from the garden soil, the term compost will be retained. The mixture of one-half clay loam and one-half river sand would fall under "sandy loam"; one-fourth clay loam and three-fourths river sand, "sandy clay loam"; and three-fourths clay loam and one-fourth river sand, "sandy clay". Hereafter, the different soil media will be called clay, sand, compost, sandy loam, sandy clay loam, and sandy clay.

Observation on recovery of the seedlings after transplanting

At the beginning of the experiment, after the seedlings were transplanted in the different media, they exhibited incipient wilting and the color of the leaves changed. These varied with the different plants and media used. The seedlings planted in compost recovered more slowly than those planted in other media.

The star apple seedlings exhibited incipient wilting for three to four days, and the leaves remained pale for sixteen to eighteen days in clay, sand, and sandy loam. They remained pale in compost, sandy clay loam, and sandy clay as long as twenty-four days. Thereafter, the plants showed signs of recovery and assumed their normal appearance.

The lanzones seedlings showed marked mottling of the leaves accompanied by a slight decrease in intensity of color. This lasted for about sixty days in compost, but only thirty-five to fifty days in sandy loam, sandy clay loam, and sandy clay. They recovered fastest in clay and sand, after twenty-eight to forty days.

The avocado seedlings took the longest time to recover, although the leaves did not become wrinkled as did the lanzones. The leaves turned yellowish and did not regain greenness until after seventy days in compost, forty-nine days in clay, sandy clay loam, and sandy clay, and sixty to sixty-three days in sand. In sandy loam, they recovered after thirty to thirty-five days.

Effects of the different soil media on the height of the seedlings

The total increase in height of the three kinds of seedlings studied and the averages of the bi-weekly measurements were greatest in the compost group (table 3). The avocado seedlings gave a total increase of 24.42 cm. during the 262 days of experimentation with an average increase of 0.85 ± 0.100 cm. for every two weeks. The closest ranking group was that of sandy clay with a total increase of 21.46 cm. and an average bi-weekly elongation of 0.79 ± 0.099 cm. The difference between the two groups is not significant, but compared with any other group, both the compost and the sandy clay loam gave significant differences.

With lanzones, the greatest increase was obtained also in plants grown in compost with a total of 17.42 cm. and an average of 0.59 ± 0.042 cm. Compared with sandy clay loam and clay, the increase in height noted in compost is not significant; but with the other groups, compost gave significant increases.

The greatest increase in height of the star apple was noted in the compost group. Compared with that of any other group, the difference is significant. The greatest total was 35.42 cm. and the next, that in clay, was 24.11 cm.

The bi-weekly average was 1.22 ± 0.039 cm. for compost and 0.83 ± 0.051 cm. for clay.

Effects of different soil media on the girth of the seedlings

In girth, the seedlings planted in the compost also gave the greatest increase. For avocado, the total increase was 0.40 cm., with an average of 0.017 ± 0.001 cm. every two weeks. The difference is significantly greater than that of any other group.

The lanzones seedlings planted in compost had a total growth of 0.28 cm., for 393 days, or an average bi-weekly increase of 0.01 ± 0.001 cm. Compared with that of sandy clay loam or clay, the difference obtained was not significant. But compared with the other groups, these three—compost, sandy clay loam, and sand—gave significant differences.

The total increase in girth of star apple seedlings planted in compost was 0.68 cm. and the average bi-weekly increment 0.023 ± 0.002 cm. or two times more than the next greatest, that of sandy loam. Those in compost outgrew all other groups significantly.

Effects of different soil media on the weight of the seedlings

With the exception of the slight increase noted in the avocado seedlings planted in sandy clay, all of the compost groups registered the greatest increase in weight. Even with the exception mentioned, the difference noted is so slight, being 53.38 ± 4.163 and 53.29 ± 4.611 gm. for the sandy clay and compost, respectively, that it may be considered negligible.

The average increase in weight registered in the two groups showed significant superiority over any other.

With lanzones, the average increase in weight was greatest in compost (15.72 ± 0.675 gm.). This group gave a significant increase over the other groups.

The average increase in weight of the star apple in compost was significantly greater than that in other groups. Likewise, the average increase in clay was significantly greater than that of sandy loam and sandy clay loam, although the increase in clay was very much less than that in compost.

General observations and discussion

One important observation is that in general all of the plants grown in compost appeared more healthy than the other seedlings. The leaves were of a deeper color, and the plants looked much more attractive than those in the other groups.

From data on hand, it is hard to conclude whether the increase in growth obtained from some of the media is a result of chemical composition. For, although the favorable effects of compost on the different seedlings used may be attributed to this, the same deduction would not hold true in the other cases. For example, the difference in increase in height between compost and sandy clay is not significant, and yet the chemical composition of the two media varied considerably so that compost contained more than three times as much phosphorus and two and one-half times as much potash as clay. It is also true that plants in the other soil media did not follow any fixed pattern in their growth increment, especially in their response to the amounts of nutrients in the soil. In this connection may be mentioned the work of Madrid (1933), in which he concluded that "suitable soil medium for the raising of cacao seedlings cannot be chosen from the results of chemical analysis alone." The best yield of pechay (292 gms.) obtained by Vibar (1931), when he used an application of Corona Special fertilizer (5-8-10) at the rate of three kilograms per 1 × 6 meters plot on clay, is not as high as the average yield obtained in compost under ordinary conditions (327 gms.).[2] Likewise, although Vera (1933) and Orig (1932), who worked with radish and mustard, respectively, obtained significant increases in yield as the result of heavier applications of commercial fertilizers, the best plants obtained were smaller than the commercial kinds often grown in sand. The highest average yield of radish obtained by Vera was 134.16 grams, whereas an average marketable root weighed about 175.35 grams.

The avocado seedlings when planted in clay gave a mean biweekly increase in height of 0.40 ± 0.031 cm.; in sand, 0.38 ± 0.070 cm. When three-fourths clay and one-fourth sand were mixed, a significant increase occurred in height, the average mean being 0.79 ± 0.099 cm. The same thing is true of the increase in weight. The avocado seedlings gave an increase in weight of 19.11 ± 1.755 gms. in clay, 26.73 ± 2.678 in sand, but 53.38 ± 4.163 in three-fourths clay and one-fourth sand. This significant increase in growth of the seedlings was probably due to the change in the physical composition of the soil.

With lanzones, the different mixtures of clay and sand resulted in an increase in weight of the seedlings over the basic constituents, although the differences were not significant.

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[2] Gonzalez, L. G., and G. Rotor Jr. Unpublished data on Philippine vegetables.

Whatever the true explanation may be for the significantly greater growth in some of the media, it is of practical importance to learn that compost, which can be prepared easily and at a comparatively low cost, is a good medium for seedlings of avocado, lanzones, and star apple.

SUMMARY OF CONCLUSIONS

1. As a result of the mechanical analysis presented in this study the different soil media used were classified according to the procedure suggested by Davis and Bennett (1927): clay loam is called "clay"; river sand, "sand"; one-half clay loam and one-half river sand, "sandy clay"; one-fourth clay loam and three-fourths river sand "sandy clay loam"; and three-fourths clay loam and one-fourth river sand, "sandy clay loam".
2. Of the three kinds of seedlings used, star apple recovered the fastest from the effects of transplanting, lanzones the next, and avocado last.
3. Lanzones and star apple seedlings grew fastest in compost, although not significantly faster than the others. With avocado, the average bi-weekly increase in weight was 0.09 gram greater in sandy clay than in compost, a very slight and very insignificant difference.
4. The seedlings grown in the compost were more attractive than any other group. The leaves were darker green in color, and the seedlings appeared to be more healthy.
5. The star apple grew fastest, avocado next, and lanzones last, in the ratio of 5.1 : 2.2 : 1.0.
6. Results of this experiment seem to indicate that the amounts of nutrients alone, as shown by the chemical analysis of the soil, do not wholly account for the best rate of growth obtained. It is clearly indicated that the physical composition of the soil plays an important part in the growth of the plants.
7. Compost was found to be a good growing medium for avocado, lanzones, and star apple seedlings.

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TABLE 1

Physical composition of different soil media[a]

CONSTITUENTS	CLAY LOAM	RIVER SAND	COMPOST	ONE-HALF CLAY LOAM, ONE-HALF RIVER SAND	ONE-FOURTH CLAY LOAM, THREE-FOURTHS RIVER SAND	THREE-FOURTHS CLAY LOAM, ONE-FOURTH RIVER SAND
	per cent	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*
Fine gravel	3.16	15.86	4.50	10.44	17.07	17.94
Coarse gravel	5.15	30.46	6.12	15.36	27.17	18.97
Medium sand	4.54	17.76	5.87	26.52	20.00	11.62
Fine sand	4.40	16.68	4.02	9.90	4.74	3.12
Very fine sand ...	3.94	3.21	3.79	1.52	0.89	2.09
Silt	18.50	1.97	18.91	6.13	3.17	9.12
Clay	17.11	4.00	9.57	7.13	4.91	10.15
Organic matter ..	42.09	8.95	45.09	21.00	21.93	25.95

[a] Figures in this table are calculated on oven-dry samples.

TABLE 2

Percentage of N, P_2O_5, and K_2O in different soil media[a]

ELEMENTS ANALYZED	CLAY LOAM	RIVER SAND	COMPOST	ONE-HALF CLAY LOAM, ONE-HALF RIVER SAND	ONE-FOURTH CLAY LOAM, THREE-FOURTHS RIVER SAND	THREE-FOURTHS CLAY LOAM, ONE-FOURTH RIVER SAND
Nitrogen (N)	0.15	0.12	0.16	0.14	0.12	0.15
Phosphorus (P_2O_5) .	0.13	0.13	0.53	0.15	0.14	0.15
Potash (K_2O)	0.27	0.33	0.80	0.21	0.29	0.37

[a] Analyzed by Department of Agricultural Chemistry, College of Agriculture.

TABLE 3

Average bi-weekly increment of certain kinds of fruit plants planted in different soil media
(Measured from February 20, 1937, to February 21, 1939)

PLANTS STUDIED	GROWTH CRITERIA	CLAY LOAM	RIVER SAND	COMPOST	½ CLAY LOAM ½ RIVER SAND	¼ CLAY LOAM ¾ RIVER SAND	¾ CLAY LOAM ¼ RIVER SAND
Avocado	Height in cm.	0.40 ± 0.031	0.48 ± 0.070	0.85 ± 0.100	0.20 ± 0.017	0.37 ± 0.025	0.79 ± 0.099
Lanzones	Height in cm.	0.46 ± 0.035	0.32 ± 0.026	0.59 ± 0.042	0.31 ± 0.019	0.47 ± 0.036	0.42 ± 0.031
Star apple	Height in cm.	0.83 ± 0.051	0.81 ± 0.069	1.22 ± 0.039	0.81 ± 0.004	0.74 ± 0.036	0.66 ± 0.041
Avocado	Girth in cm.	0.007 ± 0.000	0.012 ± 0.001	0.017 ± 0.001	0.007 ± 0.001	0.009 ± 0.001	0.012 ± 0.001
Lanzones	Girth in cm.	0.009 ± 0.001	0.006 ± 0.001	0.01 ± 0.001	0.006 ± 0.001	0.009 ± 0.000	0.007 ± 0.001
Star apple	Girth in cm.	0.012 ± 0.001	0.012 ± 0.001	0.023 ± 0.002	0.013 ± 0.001	0.011 ± 0.001	0.012 ± 0.001
Avocado	Difference in weight after one year—grams	19.11 ± 1.755	26.73 ± 2.678	53.29 ± 4.611	14.15 ± 4.274	25.21 ± 1.828	53.38 ± 4.163
Lanzones	Difference in weight after one year—grams	6.63 ± 0.582	7.71 ± 1.362	15.72 ± 0.675	8.35 ± 0.487	9.83 ± 1.081	9.82 ± 0.710
Star apple	Difference in weight after one year—grams	56.03 ± 3.097	46.35 ± 2.229	169.36 ± 0.019	43.74 ± 2.220	42.72 ± 2.815	52.79 ± 2.230

COLLEGE AND ALUMNI NOTES

President Manuel L. Quezon, accompanied by U. P. President B. M. Gonzalez, visited the College on November 21. At a special convocation of students of the College and the School of Forestry at Baker Hall, President Quezon lauded scientific farming as a profession for young men of the Philippines. His sustained interest in the College of Agriculture is due to his firm belief that the country's future lies greatly in the hands of trained farmers. After the convocation, the President discussed some of the College problems with University and College officials. As a result of his visit, steps are in progress to widen the road from San Antonio to the College gate.

The College Committee on Drama and Music presented three one-act plays in the evening of December 2, at Baker Hall. The three plays were *Suppressed Desires* by S. Glaspell and G. C. Cook, directed by Mr. M. V. Arnaldo; *War Brides* by M. Craig Wentworth, directed by Prof. J. D. Diaz; and *The Locked Chest* by J. Masefield, directed by Prof. R. M. Mack.

The Manila-Los Baños inter-faculty annual bridge tournament was played at Molawin Hall on December 3, with the Los Baños players acting as hosts to the Manila visitors. The Los Baños faculty won by a narrow margin over the Manila aggregation.

The third annual Farmers' Day, which is being sponsored by the class in Agricultural Economics 1 under Mr. M. V. Arnaldo, was held on November 30 at Higamot Hill on the College Farm. Farmer coöperators in farm bookkeeping and accounting were guests of the class for the day. A program was held for the entertainment of the farmers. Dean Uichanco was the guest speaker. Luncheon was served and games were played.

The University inter-unit carnival track relays were held on the College grounds in the afternoon of December 10, with Mr. N. Machan, the Assistant Physical Director, in charge of the meet. Unit

III representing the Los Baños Colleges won over Units I and II representing the Manila Colleges by capturing three first and one second places out of four events played in the afternoon. Incidentally, this is the eleventh successive year that this meet has been won by the Los Baños Colleges.

The Rizal Center Fraternity, Los Baños Chapter, were hosts to the faculty at a Christmas party in the afternoon of December 13, at Molawin Hall.

Mr. Alfonso B. Castro, '39, was recently appointed Assistant Instructor in soils vice Mr. J. P. Mamisao resigned.

The following papers were read before the regular meeting of the Los Baños Biological Club on December 14:

The preparation of alcoholic beverages and liqueurs. By M. R. Monsalud
Observations on the normal hemoglobin content of the Los Baños Cantonese chicken. By L. P. Zialcita and F. M. Fronda.

A study of the relation between length of storage of corms and maturity and yields of gladiolus. By V. M. Dawis.

THE PHOSPHORUS-FIXING CAPACITY OF SOME PHILIPPINE SOILS[1]

N. L. GALVEZ AND C. O. DINULOS
Of the Department of Soils

Phosphorus fixation in soils influences the availability of the water soluble phosphorus in that it lowers the concentration of available phosphorus in the soil solution. This is true not only in the soil phosphorus but also in the soluble phosphatic fertilizers added to the soils. For this reason data on the ability of some Philippine soils to fix phosphorus in a form which is soluble with difficulty should be of value to Philippine farmers. It may provide an index of the amount of phosphatic fertilizers which may be added in order to get the best results and at the same time may throw light on why an application of a certain amount of phosphatic fertilizer does not give a response.

Crawley (1902), Schreiner and Failyer (1906), Fraps (1922), Fudge (1928), and Gaarder (1930) state that phosphorus is fixed by soils the moment it comes in contact with the soil particles and that clay soils fix phosphorus more rapidly than sandy soils. The work of Beater (1937) on the measurement of phosphate fixation in soils gives a comprehensive review of the literature on the different theories concerned in this phenomenon. Because of this, no attempt is made to report them again in this paper.

The main object of the present study was to determine the amount of phosphorus that can be fixed by some composite samples of Philippine soils and to find out whether or not a relation exists between the amount of phosphorus fixed and the colloid content and also between the colloid content and the water-holding capacity.

MATERIALS AND METHODS

The soil samples used in this work were fractions of the soils studied by Golez (1938). The phosphorus-fixing capacity of these samples was determined in accordance with the technique of Heck

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[1] Experiment Station contribution No. 1340.

(1934), the colloid content with that of Bouyoucos (1930), and the water-holding capacity with that of Vageler and Alten (1931).

RESULTS AND DISCUSSION

The results of the different determinations are given in table 1. As the figures stand in this table, it is very evident that the amount of P_2O_5 fixed by the different samples collected from the Baguio region varies. It ranges from 12.40 mgm. to 30.75 mgm. per 100 grams of oven-dry sample. Likewise the colloid content is not constant. Its lowest value is 29.47 per cent while the highest is 78.70 per cent. The data for the water-holding capacity shows a similar tendency and fluctuates from 23.47 to 44.57 per cent.

The inconsistency in the amount of P_2O_5 reverted into unavailable form, of colloids, and in the water-holding capacity is also apparent in the samples from Bicol, Cavite, Maquiling area, Mindanao, and Cebu. These results bring out the fact that soils are heterogeneous matter. Since the different samples vary in their ability to fix phosphorus, it is necessary in the addition of soluble phosphatic fertilizers to give an allowance for the amount of P_2O_5 that might be converted by the soils into an unavailable form. This reveals also that the best rate of application in a certain area may or may not be the optimum amount in another area under similar conditions.

In table 1 the data for the subsoils are also given. It may be seen in this table that the figures for the phosphorus-fixing power, colloid content, and water-holding capacity corroborate those of the surface soils in that the different samples do not have consistent values.

The averages of the data in table 1 are given in table 2.

The data in tables 1 and 2 were treated statistically and are given in tables 3, 4, and 5.

In table 3, it may be seen that in the comparison of the mean amount of P_2O_5 fixed by the surface soils, the following differences are significant: Baguio-Cavite, Baguio-Maquiling, Bicol-Cavite, Cavite-Mindanao, Cavite-Cebu, and Maquiling-Mindanao. The amount of P_2O_5 fixed by these regions is not homogeneous but heterogeneous. The samples from Baguio have higher phosphorus-fixing capacity than those from Cavite and Maquiling. Those from Bicol, Mindanao, and Cebu have more fixed—P_2O_5 than those from Cavite. The difference in the mean amount of P_2O_5 fixed by the samples from

Maquiling and Mindanao is in favor of Mindanao. The rest of the differences are insignificant.

The conclusion, which one may draw from the study of the mean difference of the colloid content, corroborates in general the facts revealed by the mean difference of the amount of P_2O_5 fixed. The water-holding capacity does not bear the same relation as the colloid content with the mean difference of the P_2O_5 fixed.

It may also be noted in table 3 that the amounts of P_2O_5 fixed by the subsoils of Baguio, Bicol, Maquiling, Mindanao, and Cebu are statistically uniform in value. This similarity may be observed further in their colloid contents. In the case of the water-holding capacity the comparisons Baguio-Bicol, Baguio-Maquiling, and Baguio-Mindanao show significant differences, the rest being insignificant.

In the comparison of the surface with the subsoils, it is very apparent (table 4) that, with the exception of the difference of the colloid content of the Maquiling samples, all the differences in the mean amount of colloid content, water-holding capacity, and P_2O_5 fixed are insignificant. This is not in conformity with the finding of Görbing (1935) wherein he reported that subsoils are more capable of converting water-soluble P_2O_5 into insoluble forms than are the surface soils.

Table 5 shows that out of six correlation coefficients on the surface, for P_2O_5 fixed and colloid content, four are positive and significant and only those two from the regions of Baguio and Maquiling are insignificant; for colloid content and water-holding capacity, only those of Maquiling and Cebu do not disclose reciprocal relation.

In the subsoils the correlation coefficients are, in the majority of cases, significant like those on the surface.

Since in the present study the number of significant correlations exceeds those of the insignificant, it may be inferred that the increase in the amount of P_2O_5 fixed and the water-holding capacity is associated with an increase in the colloid content. This is in accord with the findings of Briggs and McLane (1907), Bouyoucos (1930), and Hibbard (1935).

SUMMARY AND CONCLUSIONS

1. The soil samples from the region of Baguio showed higher phosphorus-fixing capacity than those from Cavite and Maquiling but were equal to those from Bicol, Mindanao, and Cebu.

2. Bicol, Mindanao, and Cebu samples were better P_2O_5-fixers than those from Cavite. Samples from Mindanao had greater ability to fix phosphorus than did those from the Maquiling area but were equal to those from Cebu and Bicol which happened to have the same phosphorus-fixing capacity as those from the Maquiling area.

3. The subsoils of Baguio, Bicol, Maquiling, Mindanao, and Cebu proved to have identical capacity in converting water-soluble phosphorus into insoluble forms.

4. With the exception of the Maquiling area samples, there were no differences in the amount of P_2O_5 fixed, colloid content, and water-holding capacity of the surface and subsoils from Baguio, Bicol, Mindanao, and Cebu.

5. Positive and significant coefficients of correlation for the amount of P_2O_5 fixed and colloid content were revealed by the soils from the regions of Bicol, Cavite, Mindanao, and Cebu; for the colloid content and water-holding capacity, by those from Baguio, Bicol, Cavite, and Maquiling.

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TABLE 1

Amount of phosphorus fixed, colloid content, and water-holding capacity of some Philippine soils based on the oven-dry samples

BAGUIO SOILS

STOCK NO.	SURFACE			SUBSOIL		
	P_2O_5 fixed per 100 grams soil	Colloids	Water-holding capacity	P_2O_5 fixed per 100 grams soil	Colloids	Water-holding capacity
	mgm.	*per cent*	*per cent*	*mgm.*	*per cent*	*per cent*
1	12.40	30.81	40.22	11.48	29.39	25.42
2	24.15	60.39	36.19	20.59	50.39	25.34
4	30.75	78.70	41.56	29.17	71.16	38.83
5	19.37	45.16	33.39	32.86	80.39	35.31
6	23.76	60.39	30.90	22.04	55.76	27.06
7 [a]	16.63	39.25	34.49	15.57	38.85	31.87
7 [b]	28.24	69.10	39.37	26.53	62.39	38.13
8 [c]	13.46	31.52	28.54	21.80	28.89	26.31
8 [d]	27.45	66.02	39.62	27.32	62.70	37.68
12	22.96	55.39	33.55	19.93	44.39	21.45
13	21.25	44.84	26.15	23.62	55.02	27.42
14	19.27	46.03	23.47	18.48	37.70	23.46
17	21.38	50.39	38.52	19.93	49.70	34.52
18	20.28	50.25	30.42	19.66	44.39	26.95
19	18.34	37.16	29.13	17.42	31.79	28.84
20	21.78	51.39	30.58	22.57	53.79	35.30
22	19.53	46.39	35.03	27.19	66.39	38.24
27	20.59	51.76	32.89	25.74	64.76	34.02
28	14.91	33.76	25.64	18.08	45.16	26.63
29	22.57	56.39	29.15	16.72	42.76	21.59
30	27.32	70.79	44.57	20.32	50.07	36.04
32	12.67	29.47	23.57	23.23	56.26	31.76
BICOL SOILS (Albay, Camarines Norte, Camarines Sur, and Sorsogon)						
1	15.84	40.10	39.12	15.11	38.16	22.22
5	23.49	59.59	29.36	26.13	66.14	29.37
9	20.85	52.70	29.65	23.76	60.10	31.64
11	2.11	4.76	20.52	6.46	16.39	24.25
15	21.25	53.76	29.30	19.93	50.39	25.24
21	7.65	19.39	19.61	11.35	28.76	24.37
23	9.76	24.79	23.25	25.34	64.07	38.79
25	13.72	34.76	27.14	31.68	80.07	52.12
28	15.44	37.70	21.40	15.31	37.76	32.46
30	19.66	49.76	24.11	24.15	61.15	32.86
36	2.77	7.07	11.35	2.11	5.39	9.84
39	26.26	64.39	37.27	23.36	59.07	32.51
42	10.42	20.25	27.57	6.07	16.07	20.48
49	23.89	59.25	35.59	20.85	50.76	30.55
51	22.96	56.44	41.67	29.30	72.42	52.40
55	20.59	49.42	31.21	17.68	40.70	28.89
57	21.38	53.79	36.16	25.47	65.39	38.53
59	20.59	53.25	20.16	30.22	73.52	42.01
64	26.66	63.76	39.01	27.58	60.25	32.50
66	30.69	66.89	31.77	21.91	54.39	33.47
71	21.13	57.45	39.53	36.16	85.39	44.17
74	30.22	68.02	36.75	31.52	77.52	38.63

[a] Baguio series.
[b] From San Juan, Basit, Maragol, Muñoz.
[c] Baguio series.
[d] From San Juan, Basit, Muñoz.

TABLE 1—(Continued)

STOCK NO.	SURFACE			SUBSOIL		
	P_2O_5 fixed per 100 grams soil	Colloids	Water-holding capacity	P_2O_5 fixed per 100 grams soil	Colloids	Water-holding capacity
	mgm.	*per cent*	*per cent*	*mgm.*	*per cent*	*per cent*
CAVITE SOILS (Tagaytay)						
820	14.38	35.76	26.85		Not available	
821	11.35	29.24	25.35			
822	6.80	14.79	21.36			
823	7.39	17.76	22.03			
824	12.80	30.84	25.52			
825	9.24	22.39	23.35			
826	17.02	42.45	27.78			
827	5.14	13.39	17.59			
831	10.16	25.70	24.55			
832	26.79	68.39	54.88			
MAQUILING AREA SOILS						
2	13.99	34.02	20.23	18.08	48.70	38.68
5	9.76	26.70	25.02	12.80	32.76	26.36
6	17.77	46.70	29.26	22.83	54.39	36.25
8	15.04	38.39	26.16	19.00	47.70	37.55
9	21.25	50.39	32.64	24.55	60.42	39.45
21	14.52	39.76	28.08	18.08	45.76	35.50
29	20.98	49.79	29.08	22.60	54.70	35.13
MINDANAO SOILS						
1	24.02	60.39	36.19	22.57	55.76	35.95
3	20.19	48.39	46.41	21.64	53.70	47.10
6	19.14	46.39	32.46	22.96	58.76	36.15
8	16.63	40.30	29.09	24.55	59.16	38.76
16	22.60	57.70	39.48	20.85	54.16	30.28
30	19.27	48.16	30.05	27.19	69.76	31.46
32	21.51	53.79	26.34	27.58	67.76	32.17
34	16.89	38.39	20.86	14.25	33.39	20.08
36	19.40	53.39	30.13	25.21	63.85	40.64
39	27.72	68.02	49.37	24.28	60.39	41.26
58	16.63	39.16	34.56	19.14	48.95	40.72
60	19.93	49.76	33.90	25.34	62.39	32.74
CEBU SOILS (Aloguinsan)						
1	17.29	43.70	29.05	21.38	53.02	38.18
2	17.95	42.39	24.30	20.72	56.39	31.11
3	14.52	35.40	25.05	16.10	40.39	39.37
4	17.02	41.39	35.78	17.82	48.42	39.42
51	13.46	34.39	19.50	11.61	28.76	17.03
55	22.57	57.76	39.47	30.09	73.39	40.21

TABLE 2

Average amount of P_2O_5 fixed, colloid content, and water-holding capacity

	P_2O_5 FIXED PER 100 GM. SOIL	COLLOIDS	WATER-HOLDING CAPACITY
	mgm.	*per cent*	*per cent*
Baguio soils			
Surface	20.86	50.24	28.95
Subsoil	21.42	51.01	30.09
Bicol soils			
Surface	18.52	45.05	29.61
Subsoil	21.42	52.90	32.60
Cavite soils			
Surface	12.11	30.07	26.93
Subsoil	—	—	—
Maquiling area soils			
Surface	16.23	29.11	27.21
Subsoil	19.70	49.20	35.56
Mindanao soils			
Surface	20.33	50.32	34.07
Subsoil	22.93	57.33	35.60
Cebu soils			
Surface	17.40	42.50	28.86
Subsoil	19.62	50.06	34.22

TABLE 8

Comparisons of the means of the amount of P_2O_5 fixed, colloid content, and water-holding capacity

REGIONS COMPARED		TOTAL DEGREES OF FREEDOM	DIFFERENCE OF MEANS			STANDARD ERROR			CONCLUSION BASED ON SNEDECOR (1938)[a]		
			P_2O_5 fixed	Colloid content	Water-holding capacity	P_2O_5 fixed	Colloid content	Water-holding capacity	P_2O_5 fixed	Colloid content	Water-holding capacity
			mgm.	*per cent*	*per cent*	*mgm.*	*per cent*	*per cent*	*mgm.*	*per cent*	*per cent*
Baguio-Bicol	Surface	42	2.34	5.19	0.66	2.00	4.74	2.54	i	i	i
	Subsoil	42	0	1.89	2.51	2.16	5.41	2.46	i	i	s
Baguio-Cavite	Surface	30	8.75	20.17	2.02	2.09	4.98	3.15	H.S.	H.S.	i
	Subsoil	30	—	—	—	—	—	—			
Baguio-Maquiling	Surface	27	4.65	21.13	1.70	2.10	5.41	2.89	s	H.S.	i
	Subsoil	27	1.72	1.81	5.47	2.03	5.28	2.36	i	i	s
Baguio-Mindanao	Surface	32	0.53	0.08	5.12	1.64	3.84	2.70	i	i	i
	Subsoil	32	1.51	6.32	5.51	1.60	4.28	2.21	i	i	s
Baguio-Cebu	Surface	26	3.46	7.74	0.09	2.21	5.02	3.40	i	i	i
	Subsoil	26	1.80	0.95	4.13	2.36	6.15	3.00	i	i	i
Bicol-Cavite	Surface	30	6.41	14.98	2.68	3.03	6.98	3.71	s	s	i
	Subsoil	30	—	—	—	—	—	—			
Bicol-Maquiling	Surface	27	2.29	15.94	2.40	3.16	7.97	3.73	i	i	i
	Subsoil	27	1.72	3.70	2.96	3.52	8.56	3.98	i	i	i

[a] Snedecor, George W. 1938. Statistical Methods. 388 p., 14.2 fig. Ames, Iowa: Collegiate Press, Inc.
i—Insignificant.
s—Significant.
H.S.—Highly significant.

TABLE 3—(Continued)

REGIONS COMPARED		TOTAL DEGREES OF FREEDOM	DIFFERENCE OF MEANS			STANDARD ERROR			CONCLUSION BASED ON SNEDECOR (1938) *a*		
			P_2O_5 fixed	Colloid content	Water-holding capacity	P_2O_5 fixed	Colloid content	Water-holding capacity	P_2O_5 fixed	Colloid content	Water-holding capacity
			mgm.	*per cent*	*per cent*	*mgm.*	*per cent*	*per cent*	*mgm.*	*per cent*	*per cent*
Bicol-Mindanao	Surface	32	1.81	5.27	4.46	2.42	5.89	3.24	i	i	i
	Subsoil	32	1.51	4.43	3.00	2.72	6.65	3.29	i	i	i
Bicol-Cebu	Surface	26	1.12	2.55	0.75	3.36	8.10	2.82	i	i	i
	Subsoil	26	1.80	2.84	1.62	3.91	9.60	4.50	i	i	i
Cavite-Maquiling	Surface	15	4.12	8.96	0.28	2.69	7.85	3.72	i	i	i
	Subsoil	15	—	—	—	—	—	—			
Cavite-Mindanao	Surface	20	8.22	20.25	7.14	2.08	5.52	3.90	H.S.	H.S.	i
	Subsoil	20	—	—	—	—	—	—			
Cavite-Cebu	Surface	14	5.29	12.43	1.93	2.18	7.48	5.12	s	i	i
	Subsoil	14	—	—	—	—	—	—			
Maquiling-Mindanao	Surface	17	4.10	21.21	7.86	1.66	5.59	3.26	s	H.S.	H.S.
	Subsoil	17	3.23	8.13	0.04	1.81	3.88	2.93	i	i	i
Maquiling-Cebu	Surface	11	1.17	13.39	1.65	0.59	7.06	3.25	i	i	i
	Subsoil	11	3.31	0.86	1.34	2.83	6.73	3.91	i	i	i
Mindanao-Cebu	Surface	16	2.93	7.82	5.20	1.62	4.47	3.95	i	i	i
	Subsoil	16	3.31	7.27	1.38	2.30	5.79	3.88	i	i	i

TABLE 4

Comparison of the mean amount of P_2O_5 fixed, colloid content, and water-holding capacity of the surface and subsoils

REGIONS	TOTAL DEGREES OF FREEDOM	DIFFERENCE OF MEANS			STANDARD ERROR		
		P_2O_5 fixed	Colloid content	Water-holding capacity	P_2O_5 fixed	Colloid content	Water-holding capacity
		mgm.	*per cent*	*per cent*	*mgm.*	*per cent*	*per cent*
Baguio Surface-Subsoils	42	0.56 [i]	0.77 [i]	1.14 [i]	1.49	3.67	1.96
Bicol Surface-Subsoils	42	2.90 [i]	7.85 [i]	2.99 [i]	2.56	6.19	2.96
Maquiling Surface-Subsoils	12	3.47 [i]	20.07 [s]	8.35 [i]	2.10	6.72	7.00
Mindanao Surface-Subsoils	22	2.60 [i]	7.01 [i]	1.53 [i]	1.42	3.83	3.07
Cebu Surface-Subsoils	10	2.22 [i]	7.56 [i]	5.36 [i]	2.82	7.05	4.88

[i] —Insignificant (Snedecor, 1938.)

[s] —Significant (*Ibid*).

TABLE 5

Coefficient of correlation between the amount of P_2O_5 fixed and colloid content and between the colloid content and water-holding capacity.

REGIONS	NUMBER OF PAIRS OF DETERMINATIONS	DEGREES OF FREEDOM	SAMPLE VALUE OF R.			
			P_2O_5 fixed-colloid content		Colloid content-water-holding capacity	
			Surface	Subsoils	Surface	Subsoils
Baguio	22	20	0.35[i]	0.95[s]	0.58[s]	0.74[s]
Bicol	22	20	0.94[s]	0.92[s]	0.66[s]	0.88[s]
Cavite	10	8	0.94[s]	...	0.92[s]	...
Maquiling	7	5	0.59[i]	0.92[s]	0.45[i]	0.83[s]
Mindanao	12	10	0.95[s]	0.95[s]	0.61[s]	0.36[i]
Cebu	6	4	0.95[s]	0.95[s]	0.82[i]	0.63[i]

[i] —Insignificant (Snedecor, 1938).
[s] —Significant (*Ibid*).

A COMPARATIVE STUDY OF THE NATIVE AND WEST INDIAN METHODS OF PREPARING COFFEE BERRIES FOR THE MARKET[1]

CONSTANCIO S. ANTENOR

WITH ONE CHART

The importance of the Philippine coffee industry and the unfortunately small amount of accurate knowledge which the Filipino coffee planters possess regarding proper methods of preparing coffee berries for the market offer great opportunity for constructive research. One of the farmer's greatest interests in the improvement of his crops is the use of proper and easier methods of preparing his products for the market. In the case of coffee culture, for example, a simpler and less costly preparation of the beans for the market adapted to local conditions should be of distinct advantage to the coffee grower.

In the Philippines two distinct methods of preparing coffee berries for market are practiced. The old process, the one that was in general use throughout the world and is still in use in some coffee producing countries, is known as the "dry method". In this process, the first step is drying; the second, hulling; and the last, sizing, or grading.

The other method is sometimes designated the "West Indian process," or "wet method" which is practiced on all large modern coffee plantations that have the necessary supply of water and enough capital for installing all required machinery and equipment. In this wet process, the first step is called pulping; the second, fermentation and washing; the third, drying; the fourth, hulling or peeling; and the last, sizing, or grading.

Importance of the problem

The different processes to which the coffee berries are subjected from the time they are harvested until they are ground determine to a large extent the quality of the product. The factors which largely influence the quality of the coffee beans are harvesting, hulling, fermenting, drying, and storing. The berries should be harvested when they attain a deep purplish crimson color. Berries which have not reached the right degree of ripeness give coffee of poor quality. Immature berries are discolored after fermentation; the silver skin remains intact after drying; and finally the beans can not be polished properly. Duration of drying determines to a large extent proper polishing and storing. Beans which are not thoroughly dried are easily broken during the polishing process and turn moldy after a few days in storage. Proper storage of the clean beans is very essential for keeping the original color and quality of the coffee beans.

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The native method of preparing coffee berries for the market does not produce the desired uniform color of raw beans because of the silver skin that remains intact on them even after the polishing process. Overripe and unripe berries when prepared by the native method are discolored even after careful hulling and polishing. A better method of preparing coffee berries for the market should, therefore, be discovered and introduced to different farms.

Time and place of the present work

The experimental study was begun on April 19, 1938, and ended on May 2, 1939. The work was performed under the Division of Perennial Crops, Department of Agronomy.

Objects of the present work

The objects of the present study were: (*a*) to find a more practical and economical method of preparing coffee berries under Philippine conditions and (*b*) to find out a method of improving the color and quality of raw coffee beans for the market.

Review of literature

According to Smith (1913) internal fermentation takes place and causes acidification in the coffee when prepared according to the dry method. He stated that the removal of slimy stratum which is done in the "West Indian" process is necessary because the drying of the seed's envelope would be retarded and a bad flavor imparted to the seeds by partial decay of the slimy stratum during the drying process.

Ukers (1922) reports some disadvantages in the dry method of coffee preparation. According to him the brownish coloration on the surface of the beans produced by this native method is due to caffetannic substances. These substances stain the silver skin or seed coat of the beans. He stated further that washed coffee beans command a better price than the coffee dried with the pulp unremoved.

Beckley (1929) concluded in his studies on coffee that a coffee planter has a better chance of improving his produce by employing the wet method because he can control the fermentation process.

Windle (1933) states that in the "West Indian" process "foxy coffee" is oftentimes produced. "Foxy coffee" is characterized by a red stain on the silver skin and frequently produces a bad smell.

MATERIALS AND METHODS

Coffee berries and equipment used

In a preliminary part of this study, 170 liters of Excelsa coffee berries were used. When it was learned later that there were not enough berries of this variety for the experiment, Robusta variety was used instead throughout the experiment. About 2,284 liters, or 1,386 kilograms, of freshly picked Robusta coffee berries were used for the wet method and about 2,050 liters, or 824 kilograms of sun-dried Robusta coffee berries for the dry method.

The equipment used was winnowing baskets, wooden mortar with pestle, "Engelberg" rice-huller, stove, a "Cushman" engine, and a coffee pulper bearing the trade mark "John Gordon".

Different methods of preparing coffee berries for market tried in this study

The native method. For drying, thin layers of the berries were spread on cement drying floors or on shallow drying baskets. The berries were stirred or turned over occasionally to permit thorough drying. The sun-drying process lasted for fifteen days during clear sunny weather and twenty to twenty-five days during cloudy weather. The berries were kept under shelter in the evening to protect them from dew and rain. After thorough drying, the outer pericarp, mesocarp, endocarp, and part of the spermoderm were removed by pounding the dried berries in a wooden mortar with a pestle. All these broken coverings of the beans were separated by winnowing the beans in shallow bamboo baskets. The broken beans were also separated from the marketable beans by hand picking. One laborer, receiving 10 centavos an hour, was employed in the pounding, winnowing, and cleaning. The weight and volume of clean, marketable, and broken beans obtained in fifty trials were recorded. The percentages of these three kinds of products were calculated.

The dry method as practiced in the College of Agriculture. The freshly harvested berries were sun-dried in a thin layer on an open dry cement floor or in shallow baskets. They were stirred occasionally with a wooden rake to insure uniform drying. In the evening the berries were kept under shelter and covered with gunny sacks to protect them from rain and dew. It was observed that during warm clear weather the sun-drying process lasted for fifteen to twenty days and during inclement weather nearly one month. After the berries were completely dried, the outer skin, the sticky pulp, the parchment or husk, and the closely adhering silver skin were removed by passing them through the "Engelberg" rice huller.

After the berries were hulled, all the broken coverings were separated from the beans by winnowing in shallow baskets. The marketable beans were graded and all broken beans separated. Three women were employed in winnowing and cleaning. One hundred trial samples of twenty liters each were treated. The percentages of weight and volume of the clean, marketable, and broken beans were calculated from the original volume and weight of each sample.

The wet method as practiced in the College of Agriculture. Each day's harvest from the College Plateau Coffee plantation was considered a sample. The berries were weighed, measured, and soaked in water overnight so as to soften the outer skin and underlying pulp sufficiently to allow its easy removal by the pulping machine. All the berries which were found floating were collected, weighed, and again measured for volume, and deducted from the original volume and weight of the harvest. Before the previously soaked berries were passed through the coffee pulper, they were graded as to size by use of sieves to facilitate pulping. The machine was adjusted for complete pulping.

After each sample was pulped, the saccharine matter was loosened by fermentation from fifteen to twenty hours in separate containers with proper labels. This process consisted in putting the pulped berries into fermentation tanks filled with water for the purpose of removing the remainder of the pulp which had not been removed in the pulping machine and the saccharine matter or slimy stratum (mesocarp) adhering to the surface of the parchment (endocarp). The pulped berries were allowed to stay under water from fifteen to twenty hours. The beans were stirred for a short time and all light beans and pulp found floating were removed. Fermentation of the pulped berries or beans did not exceed twenty-four hours. After the fermentation, which loosened the remaining pulp and also softened the membranous covering, the beans were thoroughly washed. The washed beans were spread out thinly on cement dry floors as in the dry method. When the parchment (endocarp) became so brittle that it could be broken into pieces between the fingers and the bean within was too hard to be dented by teeth or finger nail, the drying process was stopped. It took five days to dry the beans in parchment.

On account of the absence of a regular coffee huller the parchment coffee was hulled, peeled, and polished by being passed through a rice huller and later winnowed and cleaned by women laborers paid 50 centavos a day of nine working hours.

The time spent for the different processes described in the foregoing methods and the separation of the marketable from the broken beans as well as the gasoline consumed by the machine were recorded. The marketable beans were also graded into two classes by being passed through an eight-millimeter mesh sieve. Grading is ordinarily done by machines that automatically separate and distribute the different beans according to size and form.

Wet method as followed in Lais-Tala Plantation, Davao. In this plantation all processes involved in the wet or "West Indian" method such as grading the berries, pulping, fermenting, washing, drying, and hulling were found similar to the methods practiced in the College of Agriculture. In the method followed at Lais-Tala plantation, Davao, however, the berries were not soaked in water but immediately passed through the coffee pulper after being weighed and graded. The pulped beans were then fermented, washed, and dried. The dried parchment coffee beans were hulled, winnowed, and cleaned. For the purpose of this study the method was followed in the College of Agriculture and compared with the other methods. The weight and volume of the beans of each sample were recorded. The removal of the silver skin from the beans was done by immersing the beans in warm water (55° to 65° C.) for two to three minutes, then drying them in the sun either on concrete floors or in shallow baskets. After two or three hours of drying, the silver skin loosened and the beans were again passed through the rice huller. This phase of the work corresponds to the polishing process in the method practiced in this College. The rice huller was so adjusted that the beans could pass through the huller without being broken. The winnowing, cleaning, and separating the marketable from broken beans were done by three women laborers of the College.

It was observed that the gradual drying process after the beans had been immersed in warm water was much better than drying under strong heat. It was also observed that very few of the beans were broken and the silver skin was easily removed when passed through the rice huller. Artificial drying was tried in the College Copra Drier and the silver skin was easily removed. The color of the beans was very similar to that of the product obtained when drying was done in the sun.

Wet method as practiced in Batangas. This method is in many respects similar to the dry method followed by the College of Agriculture. Instead of a coffee pulping machine used in the College, a home-made wooden coffee pulper was employed in breaking the pulp of the freshly picked berries. The broken pulp was separated from the beans by hand. The coffee beans were then fermented in heaps on cement floors or rectangular shallow bamboo baskets and washed. The washed beans were sun-dried for five days and then the dried beans were hulled in a rice mill. The broken hull and part of the silver skin was separated by winnowing. Twenty samples of three liters each were cleaned by this method. One laborer paid 10 centavos an hour was employed for this work. The percentages of the clean, marketable, and broken beans by weight and volume of each sample were determined.

Prices offered by Manila buyers

On account of the lack of available information as regards prices for clean bean coffee in Los Baños, the Bureau of Commerce and certain private companies in Manila were consulted. Samples of beans cleaned by different methods were shown for appraisal. In big companies, like the Pacific Commercial Company, prices of coffee are determined by a cup quality test. Coffee beans are given trade values according to their cup characteristics. From the results of several consultations made in Manila regarding the prices of coffee, the National Produce Exchange on May 17, 1939, gave the following prices to the samples prepared with the different methods described in this paper.

College Robusta No. 1 prepared with the Davao method, ₱19.00 per picul.

College Robusta No. 2 prepared with the College wet method, ₱17.50 per picul.

College Robusta No. 3 prepared with the College dry method, Batangas method, and the native method, ₱16.50 per picul.

Cost of preparation

In order to determine which method is the most economical, all the expenses incurred in preparing the berries under each method were recorded. From these results, the cost of preparing one picul under each method was calculated.

Color of the beans under each method

All coffee buyers judge the raw coffee beans by their appearance and color to determine the merit of the coffee they are buying. A sample representing the product of each method was examined and the beans were sorted according to Ridgway's *Color Standards and Color Nomenclature* (1912), table 4. From one sample the beans were separated into different colors and their percentages determined by considering the whole sample as equivalent to 100 per cent.

RESULTS

The results obtained in this study are summarized in tables 1 to 4. The mean percentages of volume and weight of clean, marketable, and broken beans prepared by the different methods are presented in table 1. Table 2 shows the cost of preparation per picul, and the price per picul as quoted by the National Produce Exchange, Manila, and the quality of the product from each method. The percentages of broken beans produced by the different methods are given in table 3. Table 4 is a result of the different color shades of beans found under each method.

DISCUSSION OF RESULTS

Amount of marketable beans

In an attempt to find out various factors which directly affect the efficiency of the different methods under study, the amounts of marketable beans obtained were analyzed graphically and statistically with the help of chart 1 and table 1. If the different amounts of marketable beans obtained by the different methods are compared, it is found that the College dry method produced more marketable beans than did the native method. The difference in favor of the College dry method can be ascribed to the use of a rice huller instead of a hand wooden mortar and pestle. The pounding in the wooden mortar produced more broken beans making a corresponding decrease in marketable beans.

In the wet process the various amounts of marketable beans obtained were also analyzed. If these amounts are compared, it is found that there is less than one per cent difference, showing that there is practically no advantage of one method over the other as regards amount of marketable beans obtained. However, the highest amount was observed in the Batangas wet method, with the Davao wet method second, and the College wet method third. These differences can be attributed to the different operations involved. In the Batangas wet method where the writer found the greatest amount of marketable beans produced, there was no polishing process which otherwise would have reduced the marketable beans greatly by an increase of broken beans. This relation is shown in the graphic representation in chart 1.

In the Davao wet method which was rated second in the production of marketable beans, the silver skin was rendered brittle and loose by the warm water treatment and drying process as previously described. When the beans were passed through the rice huller 0.48 ± 0.04 per cent by weight were broken. In the College wet method, the amount of broken beans observed during the polishing process, which was 0.45 ± 0.04 per cent by weight, had also relatively decreased the amount of marketable beans to 24.08 ± 0.17 per cent by weight.

Amount of broken beans from different methods

The statistical study and analysis of the mean percentages and volume and weight of clean, marketable, and broken beans are shown in table 1. A summary of such data is presented in chart 1.

Inspection of chart 1 and the data presented in table 1 discloses the fact that the Batangas wet method gave the smallest variation in amount of broken beans. This method produced the fewest broken beans—only 0.23 ± 0.03 per cent by volume and 0.25 ± 0.01 per cent by weight of the fresh berries. The berries were first pulped, and the beans fermented, washed, and dried in parchment. The parchment of the bean became very brittle and was easily removed when passed through the rice huller. Since the silver skin was not totally removed from the beans, they had a rather poor color.

The College wet method and Davao wet method rank second in this respect. The difference between the College and the Davao wet methods in the amount of broken beans which is 0.06 ± 0.05 per cent by volume and 0.03 ± 0.05 per cent by weight is negligible. The apparent difference between the amounts of broken beans obtained in the dry and wet methods may be accounted for by the dif-

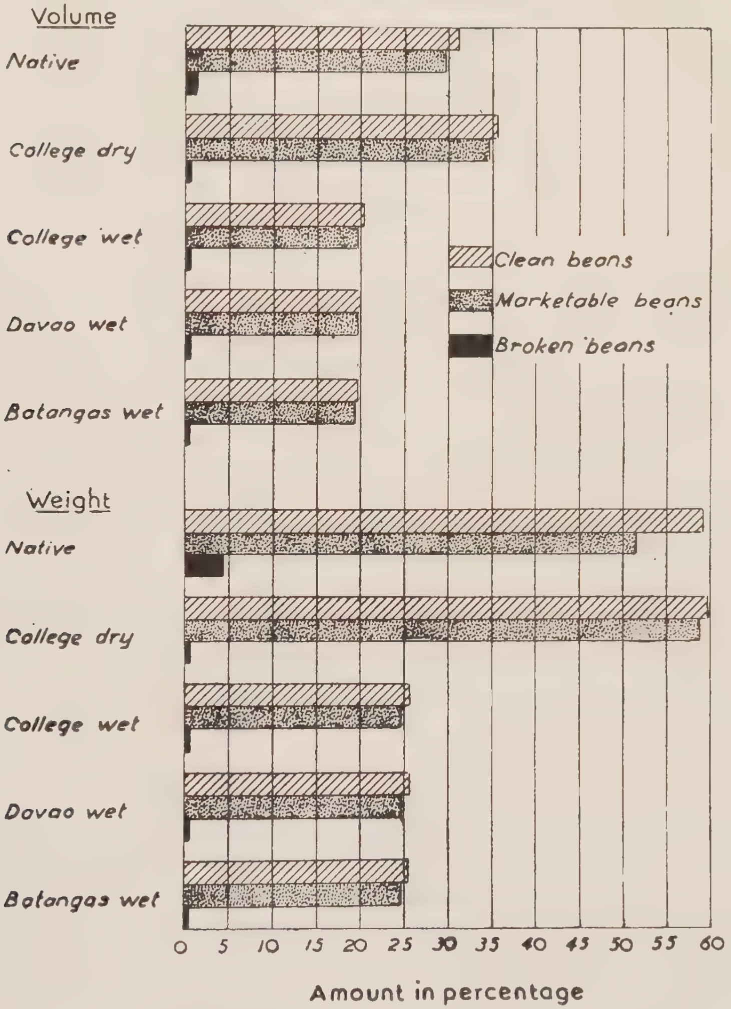

Chart 1.—Volume and weight of clean, marketable, and broken beans in percentages.

ferent forms of the berries which were pulped and the methods of preparation and equipment used. Table 3 shows the differences between the various amounts of broken beans by volume and by weight produced by the different methods. When the amounts and percentages of broken beans obtained from the dry and wet methods of preparation were compared, marked differences were found. The differences were consistently higher in the former than in the latter method. In the Native method 2.62 ± 0.07 per cent by volume and 4.36 ± 0.10 per cent by weight were broken. In the College dry method the amount of broken beans was only 0.69 ± 0.03 per cent by volume and 0.80 ± 0.03 per cent by weight of the dried berries. In this method the berries were sun-dried after which they were pulped and hulled with a rice huller, whereas in the Native method the dried berries were pounded in a wooden mortar with a pestle. Pounding had produced more broken beans. In the wet processes, the broken beans did not exceed more than 0.5 per cent both by weight and by volume of the fresh berries.

In the wet methods pulping was done while the berries were fresh and the coffee beans in parchment were thoroughly dried before they were passed through the rice huller. Complete drying of the parchment coffee rendered the hull fragile and easily broken and hence fewer beans were broken during the hulling process.

In the College wet method and Davao method the amount and percentages of broken beans were almost the same. The methods of preparation in both cases were similar. The same kind of machine and materials were used for both methods.

Cost of preparation

From the economic and practical point of view, cost of preparation is considered as one of the guides in determining the best method of preparing coffee berries for market. All the expenses incurred in preparing one picul of marketable beans in each method described in this study are summed up in table 2. This table shows that the cost of preparing one picul of coffee beans ranged from ₱5.03 to ₱13.30. It was found that the College dry method required only ₱5.03 to prepare one picul of marketable coffee beans, while the Native method required ₱13.30 to prepare the same amount. That the College dry method gave the lowest cost was due to the fact that the berries were thoroughly sun-dried and passed once through the rice-hulling machine. The College dry method was the easiest to follow of all the other methods tried in this study. That the native method gave the highest cost of preparation was attributed to the pounding of the sun-dried berries in a hand wooden mortar with pestles. The process is rather expensive and tedious. That the Batangas wet method gave the second highest cost of preparation per picul of marketable beans was due to the incomplete pulping in a home-made wooden pulper. The pulp which was partly removed was separated by hand. This entailed a great amount of hand labor with less production.

Because there was no appreciable difference between the processes of the Davao and College wet methods in preparing the coffee berries for market, the costs of preparation per picul for both methods were found to be almost the same.

Color of the beans

It will be seen in table 2 that the Davao wet method produced the best marketable beans, with the College wet method second, and all the rest third. The beans produced with the Davao wet method can be compared favorably with the first class Java Robusta No. 1. That the Davao wet method had 60 per cent pale olive-buff, 35 per cent olive-buff, and 5 per cent deep olive-buff and produced the best, or first class, beans was due to the complete removal of the silver skins just after hulling. That the College wet method gave second class raw beans, had 25 per cent deep olive-buff, 15 per cent dark olive-buff, 30 per cent deep olive, and 30 per cent avellaneous was due to the incomplete removal of the silver skin during the polishing process.

The beans produced with the Native method, College dry method, and Batangas wet method were classified third class beans because of poor color. This poor color was due to the presence of dark and discolored beans in the products obtained with all the three methods just mentioned and to the unremoved and stained silver skin which remained adhering to the surface of the beans. According to Ukers (1922) the brownish coloration is due to the action of caffetannic substances during fermentation.

SUMMARY AND CONCLUSIONS

This paper reports the results of a comparative study of different methods of preparing coffee berries for market. From the experimental results obtained, the following generalizations and conclusions are given:

1. Of the different wet or fermentation processes tried in this work, the Davao method was found to be the most practical and economical process in cleaning coffee berries, the cost of preparation being ₱5.78 per picul; of the dry methods the best found was the College dry method, the cost of preparation with it being ₱5.03 per picul.

2. The chief foodstuff buyer of the Pacific Commercial Company, Manila, classified the sample prepared by the Davao method as Java Robusta No. 1 (first class Java Robusta), according to the general appearance of the beans. He described the beans as rather small. The treasurer of the National Produce Exchange, Bureau of Commerce, Manila, classified the sample from the product obtained by the Davao method as Robusta No. 1, the one prepared by the College wet method as Robusta No. 2, and the rest of the samples as Robusta No. 3, according to general appearance and uniformity of the color, amount of broken beans, presence of foreign materials, and pulps in the product.

The beans produced with the Davao wet method had the best color and appearance; the prepared beans or the marketable produce was similar in color to the first class Java Robusta which was quoted at ₱22.00 to ₱24.00 per picul (63.25 kgm.) in the market on May 17, 1939.

3. The College dry method, and the Davao and the College wet methods of preparing berries for market could be used in large scale production.

4. Success of the dry method depends largely on the prevalence of clear warm weather over a long period; this cannot always be expected in many coffee growing provinces in the Philippines.

5. The most successful process found for removing the silver skin was by immersing the clean beans in warm water (55° to 65°C) for two or three minutes, followed immediately by drying until the closely adhering silver skin was easily removed by making slight abrasion with the fingers and then passing the beans through a hulling Machine. The process of cleaning, from pulping of the freshly picked berries to the production of the clean beans, must not be delayed in order to remove successfully the silver skin, and the fermentation process must also be controlled to improve the color and appearance of the marketable beans.

6. Size, shape, and color of the raw marketable beans are important factors in determining commercial values.

7. The percentage of marketable beans by weight obtained from each of the methods used in this study is as follows: Native method, 53.02 ± 0.03 per cent; College dry method, 57.62 ± 0.18 per cent; College wet method, 24.08 ± 0.17 per cent; Davao wet method, 24.84 ± 0.23 per cent; and Batangas wet method, 25.01 ± 0.15 per cent.

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TABLE 1

Analysis of the mean percentages of volume and weight of clean, marketable, and broken beans prepared by the different methods

METHOD	MEAN	STANDARD DEVIATION	COEFFICIENT OF VARIATION
	per cent		
Native method			
Clean			
volume	32.10 ± 0.11	1.20 ± 0.08	3.74 ± 0.22
weight	57.50 ± 0.13	1.33 ± 0.09	2.31 ± 0.16
Marketable			
volume	29.62 ± 0.07	1.41 ± 0.05	2.53 ± 0.17
weight	53.02 ± 0.03	1.34 ± 0.09	2.54 ± 0.17
Broken			
volume	2.62 ± 0.07	0.75 ± 0.05	28.64 ± 0.08
weight	4.36 ± 0.10	1.08 ± 0.07	24.79 ± 0.08
College dry method			
Clean			
volume	35.64 ± 0.18	2.69 ± 0.13	7.54 ± 0.36
weight	57.99 ± 0.19	2.76 ± 0.13	4.76 ± 0.23
Marketable			
volume	34.89 ± 0.17	2.54 ± 0.12	7.29 ± 0.35
weight	57.62 ± 0.18	2.73 ± 0.13	4.84 ± 0.23
Broken			
volume	0.69 ± 0.03	0.47 ± 0.02	68.29 ± 0.07
weight	0.80 ± 0.03	0.51 ± 0.02	63.26 ± 0.07
College wet method			
Clean			
volume	20.72 ± 0.23	1.53 ± 0.16	7.39 ± 0.79
weight	25.54 ± 0.16	1.04 ± 0.11	4.09 ± 0.44
Marketable			
volume	20.27 ± 0.22	1.46 ± 0.16	7.22 ± 0.77
weight	24.08 ± 0.17	1.10 ± 0.12	4.58 ± 0.49
Broken			
volume	0.40 ± 0.03	0.23 ± 0.02	57.28 ± 0.16
weight	0.45 ± 0.04	0.27 ± 0.03	56.19 ± 0.16

TABLE 1—(Continued)

METHOD	MEAN	STANDARD DEVIATION	COEFFICIENT OF VARIATION
Davao wet method	*per cent*		
Clean			
volume	20.34 ± 0.19	1.27 ± 0.14	6.25 ± 0.67
weight	25.50 ± 0.24	1.58 ± 0.17	6.20 ± 0.66
Marketable			
volume	19.89 ± 0.24	1.58 ± 0.17	7.95 ± 0.85
weight	24.84 ± 0.23	1.52 ± 0.16	6.11 ± 0.65
Broken			
volume	0.46 ± 0.04	0.23 ± 0.02	50.78 ± 0.15
weight	0.48 ± 0.04	0.26 ± 0.03	53.67 ± 0.16
Batangas wet method			
Clean			
volume	19.17 ± 0.24	1.59 ± 0.17	8.32 ± 0.89
weight	25.26 ± 0.15	0.98 ± 0.10	3.87 ± 0.41
Marketable			
volume	19.07 ± 0.23	1.55 ± 0.16	8.15 ± 0.87
weight	25.01 ± 0.15	1.04 ± 0.11	4.16 ± 0.44
Broken			
volume	0.23 ± 0.03	0.06 ± 0.01	24.25 ± 0.13
weight	0.25 ± 0.01	0.09 ± 0.01	34.78 ± 0.14

TABLE 2

Cost of preparing a picul of raw beans, quality of marketable beans, and Manila prices of products obtained with the different methods of preparation

METHOD	COST OF PREPARING PER PICUL	QUALITY OF PRODUCT	MANILA PRICE [a]	DIFFERENCE
	pesos	*College Robusta*	*pesos*	*pesos*
Native method	13.30	Number 3	16.50	3.20
College dry method	5.03	Number 3	16.50	11.47
College wet method	6.20	Number 2	17.50	11.30
Davao wet method	5.78	Number 1	19.00	13.22
Batangas wet method	11.15	Number 3	16.50	5.35

[a] Prices per picul (63.25 kgm.) quoted by the National Produce Exchange, Bureau of Commerce, Manila, on May 17, 1939.

TABLE 3

Broken beans produced with the different methods in 2,050.00 liters dried berries and 2,284.22 liters fresh berries

METHOD	NO. OF TRIALS	VOLUME	WEIGHT
		per cent	*per cent*
Native method	50	2.62 ± 0.07	4.36 ± 0.10
Davao wet method	20	0.46 ± 0.04	0.48 ± 0.04
Difference		2.16 ± 0.08	3.88 ± 0.10
College dry method	100	0.69 ± 0.03	0.80 ± 0.03
Davao wet method	20	0.46 ± 0.04	0.48 ± 0.04
Difference		0.23 ± 0.05	0.32 ± 0.05
College wet method	20	0.40 ± 0.03	0.45 ± 0.04
Davao wet method	20	0.46 ± 0.04	0.48 ± 0.04
Difference		0.06 ± 0.05	0.03 ± 0.05
Native method	50	2.62 ± 0.07	4.36 ± 0.10
College wet method	20	0.40 ± 0.03	0.45 ± 0.04
Difference		2.22 ± 0.07	3.91 ± 0.10
College dry method	100	0.69 ± 0.03	0.80 ± 0.03
College wet method	20	0.40 ± 0.03	0.45 ± 0.04
Difference		0.29 ± 0.04	0.35 ± 0.05
Native method	50	2.62 ± 0.07	4.36 ± 0.10
College dry method	100	0.69 ± 0.03	0.80 ± 0.03
Difference		1.93 ± 0.07	3.56 ± 0.10
College wet method	20	0.40 ± 0.03	0.45 ± 0.04
Batangas wet method	20	0.23 ± 0.03	0.25 ± 0.01
Difference		0.17 ± 0.04	0.20 ± 0.04

TABLE 4

Colors of marketable Robusta coffee beans in each product

METHODS	QUALITY OF PRODUCTS	DESCRIPTION OF COLOR OF BEANS	AMOUNT OF BEANS
		Designation	*per cent*
Native	No. 3	Light buff (45% white; 55% colored)	10
		Antimony yellow (9.5% white; 90.5% colored)	15
		Buckthorn brown (55.0% colored 45.0% black)	20
		Dresden brown (29.5% colored 70.5% black)	30
		Mummy brown (12.5% colored 87.5% black)	25
		Color denotes 65% orange; 35% yellow [a]	
College dry	No. 3	Light Russet-Vinaceous (9.5% white; 90.5% colored)	35
		Russet-Vinaceous (20% red; 80% orange)	15
		Sorghum brown (55% colored; 45% black)	20
		Hay's brown (29.5% colored; 70.5% black)	10
		Light seal brown (12.5% colored; 87.5% black)	20
		Color denotes 20% red; 80% orange [b]	
College wet	No. 2	Deep olive-buff (9.5 white; 90.5% colored)	25
		Dark olive-buff (5.0% white; 95.0% colored)	15
		Deep olive (29.5% colored; 70.5% black)	30
		Avellaneous (9.5% white; 90.5% colored)	30
		Color denotes 25% orange; 75% yellow [c]	
Davao wet	No. 1	Pale olive-buff (45% white; 55% colored)	60
		Olive-buff (22.5% white; 77.5% colored)	35
		Deep olive (9.5% white; 90.5% colored)	5
		Color denotes 25% orange; 75% yellow [d]	
Batangas wet	No. 3	Warm buff (22.5% white; 77.5% colored)	35
		Buckthorn brown (55% colored; 45.0% black)	35
		Dresden brown (29.5% colored; 70.5% black)	10
		Mummy brown (12.5% colored; 87.5% black)	20
		Color denotes 65% orange; 35% yellow [e]	

[a] A round panel was painted 65 per cent orange and 35 per cent yellow and then rotated quickly. The color shade shown by the panel during the rotation denotes the amount of color mixed with either black or white.

[b, c, d, e] The procedure was the same as in ([a]).

THE FOOD OF 158 FAMILIES IN RAMAIN, LANAO[1]

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Ramain is a town on the northeast coast of Lanao Lake in the province of Lanao. It is the native town of Sultan Sa Ramain, one of the most progressive men in Mindanao. The chief occupation of the people is farming—out of 158 heads of families in 1937, 129 were farmers. The farms were very well kept.

The method employed (the inventory method, Morey, 1933), the apparatus used in the collection of data, and the standard used in the calculation of man units were the same as those used by Santos, Villanueva, and Silva (1936), Santos (1939), Gutierrez and Santos (1938), and Santos and Demeterio (1939) in their studies on the foods in the towns of Santa Catalina, Ilocos Sur; Paoay, Ilocos Norte; Pototan, Iloilo; Calabanga, Camarines Sur; Paco District, Manila; and Macrohon, Leyte. The proximate analyses of most of the food materials were taken from the same sources. Several materials were analyzed by Mrs. M. Manahan-Ylagan of the College of Agriculture. The actual collection of data was made from April 20 to June 19, 1937 by Mr. Limpi Macapondag, a native of Ramain, under the close supervision of the junior author.

Observations

It was not uncommon for two, three, or more families to live in the same house or even in the same room. That they could live in such intimate contact and in peace showed their high sense of respect for one another's property and also their excellent spirit of cooperation.

Calendars were not popular. The ages of persons were usually calculated by comparing them with those of trees planted around the premises or with some important event such as war, time of oath of office of some official, purchase or sale of important domestic animal, etc.

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[1] Experiment Station contribution No. 1342. Part of the expense of this investigation was defrayed by a grant-in-aid from the National Research Council. Read before the Fifth Philippine Science Convention, February 22, 1939.

In general, the people of this town worried less about their food than the people in the Visayan Islands and in Luzon. Oftentimes the food materials, especially vegetables, were gathered just during the time of meal preparation.

Results and summary

Some of the data are given in tables 1 to 8, and are summarized as follows:

1. The average number of persons in a family was 4, with a range of from 2 to 10. There were 576 persons in all. There were 209 men and 220 women over 14 years old. There was only one man (65 years) over 60 and no woman.

2. The average weight of 209 men over 14 years of age was 53 kilos. The heaviest man weighed 68, and the heaviest woman, 70 kilos.

3. One hundred forty families had only two meals, lunch and supper, a day.

4. The most common food materials eaten besides rice were dried fish, mudfish (fresh), onions, pako [*Athyrium esculentum* (Retz.) Copel.], lensiman or golasiman (*Portulaca oleracea* Linn.), shrimp, cabonter (*Nymphaea* sp.), gabi leaves, cassava leaves, and bamboo shoots. Pork was not used. Milk and other dairy products were not used either. Only one family used sugar during the day the data were collected.

5. Of the 158 families, 89 per cent had an average daily man unit protein intake of 70 grams or over; 96 per cent, a carbohydrate intake of 350 grams or over; and 96 per cent, a caloric intake of 2000 or over. However, only 7 per cent had a fat intake of 30 grams or over.

6. Compared with other towns previously studied, the intakes of proteins, carbohydrates, and calories in Ramain were higher. However, the fat was the same as in Macrohon, higher than in Santa Catalina and Pototan, but lower than in Paoay and Calabanga.

7. The ratio of calories from proteins to total calories was satisfactory and both proteins and calories per kilo body weight were high.

8. Seventy-one per cent of the proteins came from plants, and cereals alone furnished 68 per cent.

9. Ninety-three per cent of the total calories came from cereals.

10. The intake of fruits and vegetables was low. These furnished only 1.75 per cent of the total calories. The amounts of phosphorus and iron appeared satisfactory, but calcium was low.

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TABLE 1

Average size of families, weights, and ages

	NUMBER OF FAMILIES	NUMBER OF PERSONS IN A FAMILY (average)	WEIGHT OF ADULT MAN (average)	HEAVIEST MAN	HEAVIEST WOMAN	OLDEST MAN	OLDEST WOMAN	MAN OVER 60 YEARS		WOMAN OVER 60 YEARS	
								Number	Per cent of total	Number	Per cent of total
			kgm.	*kgm.*	*kgm.*	*years*	*years*				
Santa Catalina	47	5	48	58	55	89	83	8	14	10	12
Paoay	59	5	50	68	57	90	102	8	13	22	13
Pototan	182	6	50	70	64	80	80	24	7	21	5
Calabanga ...	165	5	52	70	60	110	85	20	8	21	8
Macrohon ...	106	6	52	83	64	90	88	17	10	12	6
Ramain	158	4	53	68	70	65	60	1	0.5	0	0

TABLE 2

Food intake and distributions of families

INTAKE	NO. OF FAMILIES	PER CENT
PROTEINS		
grams		
Below 50	3	2
50–59	10	6
60–69	5	3
70–79	19	12
80–89	14	9
90 or above	107	68
FATS		
grams		
Below 10	3	2
10–19	85	54
20–29	59	37
30–39	7	4
40–49	1	1
50 or above	3	2
CARBOHYDRATES		
grams		
Below 350	6	4
350–449	12	8
450–549	35	22
550–649	65	41
650–749	27	17
750 or above	13	8
CALORIES		
Below 2000	7	4
2000–2499	25	16
2500–2999	31	20
3000–3499	71	45
3500–3999	13	8
4000 or above	11	7

TABLE 3

Percentage of families with satisfactory intake

	PROTEINS 70 GRAMS OR OVER	FATS 30 GRAMS OR OVER	CARBOHYDRATES 350 GRAMS OR OVER	CALORIES 2000 OR OVER
	per cent	*per cent*	*per cent*	*per cent*
Santa Catalina .	30	9	79	64
Paoay	41	29	83	71
Pototan	5	0	65	29
Calabanga	43	53	97	95
Macrohon	49	18	65	58
Ramain	89	7	96	96

TABLE 4

Average intake per man unit per day

FAMILIES	PROTEINS	FATS	CARBOHYDRATES	SALTS	FUEL VALUE
	grams	*grams*	*grams*	*grams*	*calories*
Santa Catalina ..	60 ± 1.69	15 ± 0.92	456 ± 11.54	24 ± 0.92	2193 ± 51.34
Paoay	70 ± 1.56	25 ± 1.28	443 ± 10.38	29 ± 1.47	2387 ± 49.71
Pototan	54 ± 0.37	13 ± 0.20	370 ± 2.94	8 ± 0.14	1831 ± 11.95
Calabanga	70 ± 1.01	33 ± 1.11	564 ± 6.78	16 ± 0.31	2895 ± 35.54
Macrohon	76 ± 1.94	21 ± 1.02	420 ± 8.33	23 ± 0.79	2223 ± 44.38
Ramain	99 ± 1.47	20 ± 0.54	592 ± 7.20	20 ± 0.43	3032 ± 38.18
			DIFFERENCES		
R—Santa Catalina	39 ± 2 24	5 ± 1.07	136 ± 13.60	(—)4 ± 1.02	839 ± 63.98
R—Paoay	29 ± 2.14	(—)5 ± 1.39	149 ± 12.63	(—)9 ± 1.53	645 ± 62.68
R—Pototan	45 ± 1.51	7 ± 0.57	222 ± 7.78	12 ± 0.45	1201 ± 40.01
R—Calabanga ...	29 ± 1.78	(—)13 ± 1.23	28 ± 9.89(x)	4 ± 0.53	137 ± 52.16(x)
R—Macrohon	23 ± 2.43	(—)1 ± 1.15(x)	172 ± 11.01	(—)3 ± 0.90	809 ± 58.54

(–) = against Ramain.
(x) = insignificant.

TABLE 5

Comparative food intake per kilo body weight and calories from protein

	PC/TC	P/KBW	C/KBW
	per cent	*grams*	*calories*
Santa Catalina, Ilocos Sur	11.2	1.25	46
Paoay, Ilocos Norte	12.0	1.40	48
Pototan, Iloilo	12.0	1.08	37
Calabanga, Camarines Sur	9.9	1.35	56
Macrohon, Leyte	14.0	1.47	43
Ramain, Lanao	13.4	1.87	57
American—medium work (Atwater, *cited by* Lusk, 1928)	15	1.79	49
Japanese (Grey, 1928)	13.2	1.78	53

TABLE 6

Distribution of proteins

	ANIMAL	PLANT	CEREALS
	per cent	*per cent*	*per cent*
Santa Catalina, Ilocos Sur	30.4	69.6	58.1
Paoay, Ilocos Norte	33.4	66.6	46.7
Pototan, Iloilo	34.9	65.1	59.1
Calabanga, Camarines Sur	30.0	70.0	63.0
Macrohon, Leyte	36.9	63.1	55.3
Ramain, Lanao	29.0	71.0	68.0
American (Rose, 1930)	60.9	39.1	29.0

TABLE 7

Percentage distribution of calories

	CEREAL GRAINS	MEAT, FISH, EGGS	MILK AND DAIRY PRODUCTS	FRUITS AND VEGETABLES	SWEET AND FATTY FOODS, ETC.
	per cent	*per cent*	*per cent*	*per cent*	*per cent*
Santa Catalina, Ilocos Sur	89.25	5.31		4.19	1.25
Paoay, Ilocos Norte	78.15	10.90	0.25	8.78	1.92
Pototan, Iloilo	90.41	5.94		2.59	1.06
Calabanga, Camarines Sur	79.40	4.33	0.05	13.31	2.92
Macrohon, Leyte	79.95	6.70	0.08	10.32	2.95
Ramain, Lanao	92.85	5.38	0.00	1.75	0.02
American (Rose, 1930) ...	30	15	13	15	27
Japanese (Grey, 1928)	66	13		15	6
North Chinese (Wu, *cited by* Concepcion, 1933)	72	6.8	0.06	8.7	12.6

TABLE 8

Comparative mineral intake

	CALCIUM	PHOSPHORUS	IRON
	grams	*grams*	*grams*
American standard (Rose, 1930)	0.690	1.320	0.015
Constabulary (Concepcion, 1937)	0.347	1.230	0.015
Macrohon (Santos and Demeterio, 1939) .	0.209	1.423	0.022
Ramain	0.197	2.188	0.017

A TRIAL CULTURE OF SAFFLOWER[1]

FERNANDO N. MABALAY

Safflower (*Carthamus tinctorius* L.) is known by several names in the Philippines. Merrill (1923) reported the following: *biri, kasubha,* and *sago* in Tagalog; *kasabha* in Visaya; and *kachumba* in Pampango. In Los Baños, Laguna, and in some towns of Batangas, the plant and its flowers are known as *kasubha* and the seeds are called *biri.*

According to Blanco (1837) safflower is grown primarily for the flowers which are used for coloring and flavoring instead of saffron, a species of *Crocus* widely cultivated throughout southern Europe for the drug and dye-stuff which it yields. He reported that the leaves were cooked and eaten as salad, and that the leaves when dried and well ground were used as a straw-colored dye, which is showy but not fixed, for cotton cloth.

In Los Baños, Laguna, and some towns in Batangas, the young plants are used as a vegetable when they are about 20 centimeters high, at which stage they are quite tender. Both the fresh and dry petals of the flowers are used for coloring confectionaries, liquors, and varnishes, and in cookery, as coloring and flavoring materials. The seeds are used as feed for chickens.

In spite of the importance of safflower as a vegetable and as a source of coloring matter and feed, no study of the plant has ever been undertaken in the Philippines.

According to Merrill (1918), safflower was undoubtedly introduced here in prehistoric times and "it is occasionally found cultivated but never wild". Again, Merrill (1923) reported that safflower was planted for dyeing purposes but was nowhere spontaneous.

This study had for its objects: (*a*) to determine what season of the year is best for planting safflower, and (*b*) to determine the cost of producing it.

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[1] Experiment Station contribution No. 1343. Prepared in the Department of Agronomy under the direction of Assistant Professor Vicente B. Aragon.

The experiment was begun in June, 1932, and closed in March. 1933, covering a period of 10 months. It was conducted in the Experiment Station field of the College of Agriculture.

MATERIALS AND METHODS

Materials

Seed. The seed used in the first planting was obtained from Maahas and San Antonic, both barrios of Los Baños, Laguna. The total amount of seed used was 1.5 gantas costing ₱0.50. For the second planting, the seed was taken from the harvest of the first planting.

The field. Two adjoining fields at the Experiment Station were used in this study. Each field had an area of 500 square meters and had been planted to corn and sweet potato. The soil was clay loam. No commercial fertilizer of any kind was applied to the land.

Methods

Cultures. There were two cultures made in this study, namely, a wet and a dry season culture. The wet season culture covered an area of 500 square meters. It was planted in June and the plants fully matured in October. Rain and strong winds occurred frequently during the wet season and, in most cases, damaged the plants. Since safflower has a weak stem, the plant can easily be blown down by the wind. It does not thrive well in very wet soil.

The dry season culture also had an area of 500 square meters. It was planted in October and the plants fully matured in March. The dry season was characterized by moderate rains which provided sufficient moisture for an apparently normal development of the plants. In the later part of the dry season, the weather was hot and less rainy evidently providing a desirable condition for the development of flowers and heads. With these favorable conditions, the safflower grew more luxuriantly than in the wet season.

Preparation of the field. The field was prepared with alternate plowing and harrowing. The field for the wet season culture was plowed three times with the native plow and harrowed with the bamboo harrow once after each plowing. The first plowing turned under the grass and other weeds and broke the soil into large clods. After the plowing, the harrow was passed over the field to pulverize partially the soil. Then the land was allowed to lie fallow for a week or so, during which time much of the weed seeds germinated. The second plowing and harrowing followed and the land was left again for a week to let late weeds grow. By this time, the soil was almost pulverized and ready for planting. But before furrows were made, the field was plowed and harrowed for the third time to lessen the cost of weeding. The field for the dry season culture was plowed three times and harrowed once after each plowing. The same operation used in the wet season culture was followed in the dry.

Bedding. With the plow the beds were laid out about 90 centimeters apart. The plow was run twice in the row in opposite directions, thus making a ridge, or bed, where the seeds were sown. On each side of the bed were two furrows serving as drainage canals.

Planting the seeds. In the wet season culture, the seeds were planted on June 21, 1932, in holes 40 centimeters apart in the row, four to six seeds to a hole. This rate of seeding was done to avoid replanting and may have been the cause of uneven stand of the plants in the field. The seeds were covered with soil from one to two centimeters thick.

The seeds began to germinate in from three to five days after planting. It was found that some of the seeds which were uncovered germinated as slowly as those that were buried deep in the soil. In most cases, the seedlings from seeds buried deep in the soil owing to a heavy rain failed to appear above the surface of the ground.

In the dry season culture the seeds were planted on October 25, 1932, in hills 40 centimeters apart in the row, at the rate of four to six seeds to a hole. The seeds were covered with soil from one to two centimeters thick. They began to germinate in from three to five days.

A week later, thinning was done by eliminating the poorer plants and leaving the healthy ones. Thinning was practiced in both the dry and the wet season planting, leaving for both cultures three plants to a hill.

Weeding. Safflower was found to be a slow growing plant and it was necessary to weed the culture continually as the plant did not have much weed controlling power.

In weeding, several garden tools were used. The hoe was found to be the most efficient tool. The trowel was used, but when the weeds were many, the hoe was used instead.

Cultivation. Weeding and cultivation went hand in hand. Whenever weeding was done with the hoe, cultivation was also done.

Cultivation with the plow was not practiced because the plants were planted in beds.

Harvesting, threshing, and winnowing. When the flowers had reached maturity, the corollas were gathered every morning and weighed. Then they were dried thoroughly in the sun. The flowers were considered matured and ready for harvest when they had turned purple. When the flowers were left ungathered for two or three days, they became a dried mass, hence no longer fit for harvesting. This is the main reason why the flowers were gathered every day. If the flowers were gathered when over-matured, they lost their natural reddish or purplish color which the market demands. If, however, they were harvested fresh and afterwards dried, the flowers retained their natural color and good appetizing smell.

The heads were considered mature and ready for harvest when the leaves, stems, and heads were thoroughly dry. The seeds were harvested by cutting the whole stem just above the ground. Then they were hauled to the seed laboratory where they were further dried and threshed.

Threshing was performed on a concrete floor. Because the stems, leaves, and heads have thorns, the seeds were threshed by beating the plants with a stick until the seeds separated from the heads. The threshed seeds were collected and winnowed with a winnowing basket. When the seeds were thoroughly cleaned, they were collected, weighed, and put in a container.

Storing the seeds and flowers. After the flowers were thoroughly dried, they were placed in a glass jar provided with a cover. It was found that the flowers kept their natural color and the good appetizing smell. No test, however, was undertaken to determine their keeping qualities.

The seeds were placed in a petroleum can provided with a cover. Although the can was not sealed, no insect pests were found afterwards attacking the seeds.

Farmers in the vicinity of Los Baños store their seeds in bamboo joints with dried banana leaves or old newspapers as stoppers. No other treatment is given the seeds; yet they remain viable at least up to the next planting season. This shows the high viability of safflower seeds.

EXPERIMENTS AND RESULTS

The results of this study are presented in tables 1 to 7. Table 1 shows the number of hours spent on the different farm operations in a field 500 square meters in area during the dry season planting and in another field of the same area during the wet.

Table 2 shows the average number of hours spent and the cost of various farm operations in the fields for the dry and the wet season cultures. The dry season culture consumed a total of 67.34 hours, the wet season 72.72 hours. The cost of labor spent for the dry season operations was ₱7.42 and for the wet season ₱8.03.

Table 3 gives the value of depreciation of the implements and the interest on the investment. The depreciation and the interest on the investment was ₱0.07 per field for the dry season and ₱0.08 for the wet season. In computing the depreciation of the implements, the formula recommended by Catambay (1931) was used.

Table 4 shows the rent of the land, the cost of the seeds used, the labor cost, and the depreciation and interest. The rent of the land was considered as ₱20.00 per hectare which is the current land rent in the vicinity of Los Baños. The total land rent for the dry season was ₱0.42 and for the wet season ₱0.42. For each culture the land was used for five months. The total cost of the seeds used was ₱0.50 for each culture. The land rent, the supply cost, the labor cost, and the depreciation and interest of the implements used amounted to ₱8.41 in the dry season and ₱9.03 in the wet per field of 500 square meters.

Table 5 gives the yield of dry corollas and of seeds. The harvest of corollas in the dry season was 1,790.7 grams, and in the wet season 465.9 grams per field of 500 square meters. The amount of seeds harvested in the dry season was 1,255 grams, and in the wet season 300 grams.

Table 6 shows the value of the harvest of the dry and the wet seasons. The cost of the flowers was ₱0.005 a gram and of the seeds, ₱0.0002 a gram. The total value of the dry season crop was ₱8.95 for the flowers and ₱0.25 for the seeds, giving a total of ₱9.20. The wet season harvest amounted to ₱2.33 for the flowers and ₱0.06 for the seeds, giving a total of ₱2.39.

Table 7 shows the difference between the cost of production and the value of the harvest from each culture. This table gives the gain or loss which is the difference between the cost of production and the value of the harvest from each culture. The dry season culture gave a gain of ₱0.79 per field and the wet season culture gave a loss of ₱6.64. This gave, on the whole, a total computed gain of ₱15.80 a hectare for the dry season and a computed total loss of ₱132.80 a hectare for the wet season culture.

DISCUSSION OF RESULTS

General Observations

Effect of weeds. It was noted that plants growing with many weeds were slender, had few branches and heads, and consequently gave a very much reduced production. This observation shows that safflower culture must be kept free from weeds in order to produce a good yield and profit for the farmer.

Pests and diseases. The worm, *Pachyzancla hipponalis* Walker [2], was found attacking the safflower. It ate the leaves and rolled itself in them to pupate.

Safflower is fairly resistant to the attack of plant diseases. Except for occasional wilting of the leaves caused by *Cercosporina carthami* and portions of the stem being attacked by Phoma blight, (*Phoma* sp.)[3] no disease was found on the plants. When these diseases appear in great numbers, it is wise to pull up and destroy the plants so as to prevent the spread of the disease. This will at least minimize the injury to the plants.

Effect of rain. It was found that rain was detrimental to the vigorous growth and development of the heads of the safflower. When the rain was heavy and continuous for some time, the head rotted especially when the seeds inside the heads had been formed. The seeds are embedded in a pilose receptacle. This hairy receptacle decays under continuous rain and, evidently, the entire head rots. If the heads did not decay and the seeds were mature, raining for several days caused the seeds to germinate inside the head. This resulted in a very low yield of seeds for harvest.

Days to flower and to mature. In the wet season culture, the plant formed heads which produced the flowers in 83 days or approximately three months after planting. The dry season planting produced flowers in 81 days.

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[2] The insect pest was identified by Dr. L. B. Uichanco of the Department of Entomology.

[3] The plant diseases were identified by Mr. E. Roldan of the Bureau of Forestry.

The wet season crop was harvested on October 14, 1932, and the dry season crop on March 13, 1933. In the wet season culture, the heads matured in 127 days after planting; in the dry season, they matured in 140 days.

It was also observed that some heads, although large, had few mature seeds or none at all. This might have been due to premature flowering of the heads as evidenced by the many undeveloped seeds found inside the flower head.

Field operations and costs

In the preparation of the field and in such other farm operations as planting, weeding, harvesting, threshing, etc., the laborer's wage was considered as ₱1.00 a day of 9 working hours. The charge for animal work was ₱1.00 a 9-hour day. These rates give an average of ₱0.11 an hour for either the man or the animal. The cost of plowing was ₱0.80 (table 2) for man and animal labor per field for the dry season culture. The wet season plowing cost ₱0.83 for man and animal labor.

Plowing. It took 7.25 hours (table 1) to plow the field three times in the dry season culture. The wet season required 7.50 hours for three plowings. This gave a total cost of ₱32.00 a hectare for three plowings in the dry season culture. The cost was ₱33.20 a hectare for three plowings during the wet season culture. This shows that the dry season plowing was ₱1.20 a hectare cheaper than the wet season plowing. In the wet season plowing, the time consumed was higher by fifteen minutes, costing ₱1.20 more per hectare than the same operation in the dry season. This difference may be due to the presence, during the rainy season, of more weeds, thus taking more time to plow.

Harrowing and furrowing. It took 2.50 hours (table 1) to harrow each field in both the dry and the wet season cultures. The cost of harrowing was ₱11.20 a hectare for three harrowings. The time spent for making the ridges or furrows was 1.65 hours (table 1). This gave a total cost of ₱7.20 a hectare for man and animal labor for each of the dry and wet season cultures.

Planting. It required 6.65 hours (table 1) to plant the field in the dry season and 5 hours in the wet season. The planting operation in the dry season required 1.65 hours longer than in the wet season planting probably because in the wet season the soil was rather soft. It was easier to cover the seeds with the feet in the wet season;

hence less time was required in planting. The cost of planting was ₱14.60 (table 2) for the dry season and ₱11.00 for the wet season culture. This shows that there was a difference of ₱3.60 in favor of the wet season planting; hence the wet season planting was ₱3.60 a hectare cheaper than the dry season planting.

Weeding. Weeding required a good deal of time, consuming 13.28 hours per field in the dry season and 33.32 hours in the wet season, or 20.04 hours more per lot in the wet than in the dry season culture largely because of the luxuriant growth of the weeds in the latter culture.

The cost of weeding was ₱29.20 a hectare in the dry season and ₱73.40 a hectare in the wet season culture. This gave a difference of ₱44.20 a hectare in favor of the dry season culture.

Harvesting. Harvesting was very expensive. The dry season crop of seeds took a longer time to mature than the wet season crop because of the many branches and heads which the dry season crop produced. In the wet season culture, there were only one or two branches produced in a plant, hence they matured at an early age.

Harvesting the flowers was slow tedious work. Because of the more vigorous growth of the plants, it required 1.50 hours more in the dry than in the wet season to harvest the entire field. The time used in the dry season for harvesting the seeds in the entire field was 4.06 hours and 1.65 hours in the wet season, giving a difference of 2.41 hours in favor of the wet season.

The cost of harvesting the entire field was ₱0.80 for the flowers and ₱0.45 for the seeds in the dry season, a total cost of ₱1.25 a field of 500 square meters or ₱25.00 a hectare in the dry season culture. In the wet season, harvesting cost ₱0.64 for the flowers and ₱0.18 for the seeds, giving a total of ₱0.82 per field of 500 square meters, or ₱16.40 a hectare. This gave a difference between the two seasons of ₱8.60 a hectare in favor of the wet season culture.

Hauling. The harvested plants were hauled from the field to the Seed Laboratory. The hauling required 0.80 hour a field for each culture. Hauling cost ₱3.60 a hectare for each season.

Threshing. Threshing consumed a total of 10 hours in the dry season culture and 1.65 hours in the wet season. The dry season harvest required 8.35 hours more than the wet season. This difference was due to the fact that the dry season harvest was very much larger than that of the wet season.

Threshing gave an average computed cost of ₱22.00 a hectare in the dry season and ₱3.60 a hectare in the wet season culture. This gave a difference of ₱18.40 a hectare in favor of the wet season culture.

Winnowing. The average time required for winnowing per field was 1.65 hours for the dry season and 0.40 hours for the wet season culture. The average cost of winnowing the harvest of the dry season culture was ₱0.18 and of the wet, ₱0.05. The average cost per hectare of this operation, therefore, was ₱3.60 in the dry and ₱0.80 in the wet season.

If all the expenses in the different farm operations are added, the total cost per field of 500 square meters for the dry season was ₱7.42 and for the wet season, ₱8.03. This gave, on the average, a difference of ₱0.61 between the two cultures or ₱12.20 a hectare in favor of the dry season culture.

Depreciation and interest

The total cost of the depreciation on the implements and interest on the investment was ₱0.07 (table 3) for the dry season and ₱0.08 for the wet season culture. This gives a total cost of depreciation and interest of ₱1.40 a hectare in the dry and ₱1.60 in the wet season. In the wet season, the implements were used longer than in the dry season, especially in weeding; hence the cost of the depreciation and of interest was statistically larger in the wet than in the dry season culture.

Cost of the seeds and land rent

Cost of the seeds. The cost of the seeds used was ₱0.50 (table 4) for each of the dry and wet season plantings. It should be remembered that from 4 to 6 seeds were planted in each hole to give allowance for those which might be washed away or eaten by ants, although only 3 plants were allowed to grow in each hill.

Land rent. As already mentioned, the total area of the field used for each culture was 500 square meters. Considering the cost of land rent as ₱20.00 a hectare a year, which is the current rental in the vicinity of Los Baños, the cost of the use of land was ₱0.42 (table 4) for each of the seasons. The land was used in each culture for a period of 5 months.

Cost of production

Labor cost (man and animal). The cost of labor was ₱7.42 (table 2) for the dry season culture and ₱8.03 for the wet. This shows that the dry season culture was ₱0.61 cheaper per field of 500 square meters, or ₱12.20 a hectare, than the wet.

Adding the cost of the depreciation and the interest, the cost of the seeds and land rent and the labor cost (man and animal) the total cost of production would be ₱8.41 (table 4) for the dry season and ₱9.03 for the wet. The dry season culture was ₱0.62 cheaper per field of 500 square meters, or ₱12.40 a hectare, than the wet.

The yield and the cost of the harvest

The yield. The dry season culture gave a computed yield per hectare of 35,814 grams (table 5) of flowers, and the wet season culture of 9,318 grams of flowers. The average difference between the dry and the wet season harvest was 26,494 grams of flowers per hectare in favor of the dry season. This difference is primarily due to the season under which each culture was planted. Plants of the wet season were slender, with few branches and small heads which undoubtedly influenced the development of small clusters, all of which caused low yield for the wet season culture. Plants of the dry season culture were vigorous and tall, each plant having developed more branches and heads than the plants of the wet season and produced larger clusters and, hence, the yield of the dry season was greater. These results show that farmers in the vicinity of Los Baños should plant safflower in the dry season only. But according to these farmers, they plant it in the dry season because it is in this season when there are many holidays, christenings, and birthday parties, on which occasions safflower is in demand for coloring and flavoring food materials. Obviously, there should be a second reason for the dry season planting.

The computed yield of seeds for the dry season culture was 25,100 grams (table 5) per hectare and for the wet season culture, 6,000 grams. This shows that the dry season production was 19,100 grams more per hectare than the wet season harvest. This difference is due to the larger heads and seeds produced by the dry season culture. Most of the flower heads of the wet season plants were small and other heads had few small seeds or none at all.

Cost of the harvests. One ganta of seeds weighed 1,742 grams and the same volume of flowers, 240 grams. At Calamba, Laguna, the current price of these flowers was ₱1.20 a ganta or ₱0.005 a gram. The price of the seeds was ₱0.30 a ganta or ₱0.0002 a gram. If the computation is based on these data, the value of the dry season harvest was ₱179.00 (table 6) per hectare for the flowers and ₱5.00 per hectare for the seeds. This gave a total sum of ₱184.00 (table 6) per hectare for both the seeds and the flowers for the dry season. The value of the wet season harvest was ₱46.60 (table 6) per hectare for the flowers and ₱1.20 per hectare for the seeds, giving a total of ₱47.80 for both the flowers and the seeds for the wet season. These figures show that the value of the produce from the dry season culture was ₱136.20 per hectare more than the wet season culture.

Profit and loss

Profit. The total expense incurred in producing safflower for the dry season was ₱8.41 (table 7) per field of 500 square meters and the value of the harvest produced from it was ₱9.20 (table 7). These figures show that there is a profit of ₱0.79 per 500 square meters or a computed gain of ₱15.80 a hectare.

Loss. The total expenditure for the wet season culture was ₱9.03 per 500 square meters of ground and the cost of the crop produced from it was ₱2.39 (table 7). These figures show that there was a computed loss of ₱132.80 a hectare in the wet season culture.

SUMMARY AND CONCLUSIONS

The culture and cost of production of safflower in both the dry and wet seasons were studied in this investigation. The results of the study may be summarized as follows:

1. The dry season crop matured 140 days after planting. The plants produced many heads which did not mature at the same time; hence, more time was required for harvesting. The wet season crop matured 127 days after planting. The plants produced from one to three heads which matured at about the same time.

2. In this experiment the dry season crop produced a computed yield of 35.814 kgm. of dry petals and 25.10 kgm. of dry seeds per hectare, while the wet season crop produced 9.318 kgm. of dry petals and 6.00 kgm. of dry seeds.

3. The computed cost of production of dry petals and seeds was ₱168.20 per hectare in the dry season and ₱180.60 in the wet season.

4. The computed market value of the harvests of petals and seeds for the dry season culture was ₱184.00 a hectare and for the wet season crop, ₱47.80 a hectare. This gives a difference of ₱136.20 a hectare in favor of the dry season culture.

5. The cost of production per kilogram of dry petals was ₱3.63 in the dry season and ₱18.12 in the wet. It cost ₱6.06 to produce one kilogram of seed in the dry and ₱27.96 in the wet season.

6. The dry season culture gave a total net gain of ₱15.80 a hectare. The wet season culture gave an approximate total loss of ₱132.80 a hectare.

7. The proper season for planting safflower is during the dry season.

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TABLE 1

Number of hours spent in the different farm operations

OPERATIONS	KINDS OF LABOR	DRY SEASON PLANTING (Field of 500 sq. m.)	WET SEASON PLANTING (Field of 500 sq. m.)	COMPUTED HOURS PER HECTARE	
		Hours spent	Hours spent	Dry season (Average)	Wet season (Average)
				hours	*hours*
Plowing	Man	7.25	7.50	145.00	150.00
	Animal	7.25	7.50	145.00	150.00
Harrowing	Man	2.50	2.50	50.00	50.00
	Animal	2.50	2.50	50.00	50.00
Furrowing	Man	1.65	1.65	33.00	33.00
	Animal	1.65	1.65	33.00	33.00
Planting	Man	6.65	5.00	133.00	100.00
Weeding	Man	13.28	33.32	265.60	666.40
Harvesting					
Flowers	Man	7.30	5.80	146.00	116.00
Seeds	Man	4.06	1.65	81.20	33.00
Hauling	Man	0.80	0.80	16.00	16.00
	Animal	0.80	0.80	16.00	16.00
Threshing	Man	10.00	1.65	200.00	33.00
Winnowing	Man	1.65	0.40	33.00	8.00
Total hours	......	67.34	72.72	1,346.80	1,454.40

TABLE 2

Average number of hours required for the different farm operations and the average cost of labor spent for the dry and wet season cultures

OPERATIONS	KINDS OF LABOR	WAGE PER HOUR	HOURS SPENT PER FIELD OF 500 SQ. M.		COST OF PRODUCTION PER CULTURE		COMPUTED COST OF PRODUCTION PER HECTARE	
			Dry season	Wet season	Dry season	Wet season	Dry season	Wet season
		pesos	*hours*	*hours*	*pesos*	*pesos*	*pesos*	*pesos*
Plowing	Man	0.11	7.25	7.50	0.80	0.83	16.00	16.60
	Animal	0.11	7.25	7.50	0.80	0.83	16.00	16.60
Harrowing	Man	0.11	2.50	2.50	0.28	0.28	5.60	5.60
	Animal	0.11	2.50	2.50	0.28	0.28	5.60	5.60
Furrowing	Man	0.11	1.65	1.65	0.18	0.18	3.60	3.60
	Animal	0.11	1.65	1.65	0.18	0.18	3.60	3.60
Planting	Man	0.11	6.65	5.00	0.73	0.55	14.60	11.00
Weeding	Man	0.11	13.28	33.32	1.46	3.67	29.20	73.40
Harvesting								
Flowers	Man	0.11	7.30	5.80	0.80	0.64	16.00	12.80
Seeds	Man	0.11	4.06	1.65	0.45	0.18	9.00	3.60
Hauling	Man	0.11	0.80	0.80	0.09	0.09	1.80	1.80
	Animal	0.11	0.80	0.80	0.09	0.09	1.80	1.80
Threshing	Man	0.11	10.00	1.65	1.10	0.18	22.00	3.60
Winnowing	Man	0.11	1.65	0.40	0.18	0.05	3.60	0.80
Total	....	....	67.34	72.72	7.42	8.03	148.40	160.60

TABLE 3

Depreciation of the implements and interest on the investment

KINDS OF IMPLEMENTS USED	COST	MAXIMUM NUMBER OF DAYS USED IN ONE YEAR	LIFE IN YEARS	ANNUAL RATE OF INTEREST	NUMBER OF DAYS USED		DEPRECIATION		INTEREST		TOTAL DEPRECIATION AND INTEREST	
					Dry season	Wet season	Dry season	Wet season	Dry season	Wet season	Dry season	Wet season
					Hours spent	Hours spent	Average cost	Average cost	Average cost	Average cost	Average cost	Average cost
	pesos			*per cent*			*pesos*	*pesos*	*pesos*	*pesos*	*pesos*	*pesos*
Plow, native .	17.00	100	4	10	8.90	9.15	0.04200	0.04315	0.00460	0.00475	0.04660	0.04790
Harrow, native	5.00	100	3	10	2.50	2.50	0.00460	0.00460	0.00025	0.00035	0.00485	0.00495
Trowel	0.40	150	2	10	7.96	19.32	0.00350	0.00850	0.00005	0.00020	0.00355	0.00870
Grub Hoe ...	0.75	100	3	10	5.32	14.00	0.00140	0.00375	0.00010	0.00030	0.00150	0.00405
Bull Cart ...	100.00	250	5	10	0.80	0.80	0.00710	0.00710	0.00240	0.00240	0.00950	0.00950
Total	—	—	—	—	25.48	45.77	0.05860	0.06710	0.00740	0.00800	0.06600	0.07510

TABLE 4

Cost of production including land rent, supply and labor costs, and depreciation and interest

	ACTUAL COST OF FIELD OF 500 SQ. M.		COMPUTED COST PER HECTARE	
	Dry season	Wet season	Dry season	Wet season
	pesos	*pesos*	*pesos*	*pesos*
Land rent (Five months)	0.42	0.42	8.40	8.40
Cost of seed (Supply cost)	0.50	0.50	10.00	10.00
Labor cost (Man and Animal)	7.42	8.03	148.40	160.60
Depreciation and interest	0.07	0.08	1.40	1.60
Total	8.41	9.03	168.20	180.60

TABLE 5

Yield of flowers and of seeds in the dry and the wet season cultures

ACTUAL YIELD OF FIELD 500 SQ. METERS IN AREA				COMPUTED YIELD PER HECTARE			
Flowers		Seeds		Flowers		Seeds	
Dry season	Wet season	Dry season	Wet season	Dry season	Wet season	Dry season	Wet season
grams	*grams*	*grams*	*grams*	*grams*	*grams*	*grams*	*grams*
1,790.7	465.9	1,255	300	35,814.0	9,318.0	25,100.0	6,000.0

TABLE 6

Value of the harvest

ACTUAL COST OF THE HARVEST PER FIELD OF 500 SQUARE METERS				COMPUTED MARKET VALUE OF THE HARVEST PER HECTARE				TOTAL MARKET VALUE OF FLOWERS AND SEEDS	
Flowers		Seeds		Flowers		Seeds			
Dry season	Wet season	Dry season	Wet season	Dry season	Wet season	Dry season	Wet season	Dry	Wet
pesos	*pesos*	*pesos*	*pesos*	*pesos*	*pesos*	*pesos*	*pesos*	*pesos*	*pesos*
8.95	2.33	0.25	0.06	179.0	46.60	5.00	1.20	184.00	47.80

TABLE 7

Difference between the cost of production and the value of the harvest

ITEMS	DRY SEASON	WET SEASON
	pesos	*pesos*
Computed cost of production per hectare	168.20	180.60
Market value of the harvest	184.00	47.80
Gain or Loss	+ 15.80	—132.80

A STUDY OF THE COLLEGE OF AGRICULTURE GRADUATES[1]

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It is important to study the nature of activities of the graduates of an educational institution. It is a way of determining whether or not the institution is accomplishing its principal objectives. Facts secured from such a study can be used as a basis for effecting curricular changes for the purpose of improving the educational program.

Attempts to discover the nature of activities of the graduates of the College of Agriculture of the University of the Philippines have been made in the past. In 1916 appeared a list of the occupations of the graduates from 1911 to 1916. (Anonymous, 1916).

Sanvictores in 1918 made a survey of the nature of the work of the 39 graduates who were employed in the former Bureau of Agriculture.

Baker (1920), in answer to charges that the graduates were failures, published the names of the alumni from 1911 to 1919 together with their occupations. His report showed that a large majority of the graduates were doing technical work in the Bureau of Agriculture. A smaller number were teaching in the College of Agriculture, and a group of similar size were engaged in farming.

Baker in 1923 again wrote on the activities of the graduates. His paper included a list of the graduates from 1911 to 1923, with their corresponding occupations. According to him, the output of the College is of two sorts: "First, and most important, is the human product; and second, the investigational and study results."

Another list appeared in 1927. Of the 468 graduates, 292 were connected with occupations directly related to agriculture. About one-third of these 292 alumni were farming or managing agricultural enterprises and two-thirds were doing agricultural work in the Bureau of Agriculture, College of Agriculture, and Bureau of Education.

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[1] Experiment Station contribution No. 1344.

Directories of alumni with their occupations have also been prepared from time to time by the Office of the Secretary of the College.

As will be noticed, the previous studies were largely confined to the listing of occupational pursuits of alumni. Hence, there is need for a more extensive investigation on the subject.

The principal objects of the study were to determine: (*a*) the occupations of graduates, (*b*) their entrance salary and their income in 1938, (*c*) ownership of land, (*d*) place of business, (*e*) marital state, and (*f*) ownership of residence.

MATERIALS AND METHODS

In the early months of 1938, copies of a questionnaire were sent to all graduates of the College of Agriculture. The following items of information were secured: occupation, business address, entrance salary, 1938 income, land area acquired, manner of land acquisition, marital state, and ownership of residence.

Replies were received from 719 of the 1175 graduates of the College. Of the 456 who did not return the questionnaire, the occupations of 339 were obtained from records in the Office of the Secretary and from information furnished by other alumni. Of the remaining 117, 47 were definitely known to be dead, while the address or whereabouts of 70 could not be determined.

RESULTS AND DISCUSSION

Occupational distribution of the graduates

The occupations of the graduates may be classified into five groups: namely, (1) educational work, including administration of educational institutions in agriculture, (2) technical work in agriculture, including administration of technical organizations, (3) farming or management of farms, (4) work slightly related to agriculture, and (5) work not related to agriculture. As may be seen in table 1, 37.0 per cent were engaged in educational work in the field of agriculture; 29.2 per cent in technical work; and 22.0 per cent in farming or managing farms. Only 6.0 per cent were in occupations only slightly related to agriculture and 5.8 in occupations not at all related to agriculture.

A survey of occupations of graduates of the New York State College of Agriculture at Cornell showed that "about one-fourth engage in farming, one-fourth in teaching, research, or extension, one-fourth in business closely allied with farming, and the remaining fourth in non-agricultural fields."[2] A comparison with these figures reveals that a much larger percentage of the graduates of the local College of Agriculture were pursuing occupations directly related to agriculture.

Nature of educational work. Of those engaged in educational work, the greatest portion were teaching agriculture in agricultural and other high schools. They numbered 147 out of 392, as may be seen in table 2. The inauguration of an extensive program of extension work has given employment to a large number of graduates in recent years. There were 96 municipal agricultural inspectors and 48 provincial agricultural supervisors. Another large group consisted of 70 agriculture and science professors and instructors in colleges, of which 51 were in the U. P. College of Agriculture.

Technical work in agriculture. Included in this group were 309 graduates engaged in diverse occupations of a technical nature, as shown in table 3. There were 81 agronomists and assistant agronomists connected with the Bureau of Plant Industry, 11 chiefs of divisions and sections, 11 station superintendents in the same bureau, 43 fiber inspectors, 43 chemists in sugar centrals, and 13 permit agents in the Philippine Sugar Administration. Several were employed as tobacco inspectors, chemists in business firms, soil technologists, fishery technologists, entomologists, plant pathologists, researchers, and technical and laboratory assistants.

Farming or managing farms. Those engaged in general farming numbered 114 out of 233; those engaged in specialized type of farming, 28 (table 4). There were 91 farm managers and hacienda agronomists.

Occupations slightly related to agriculture. Of the 63 graduates in this group, 44 were Philippine Army officers whose work was concerned with agricultural instruction of trainees and development of agricultural projects in military cadres. The others under this group were garden teachers in elementary schools, proprietors of agricultural enterprises, merchants dealing in agricultural commodities, and forest rangers.

Occupations not related to agriculture. The 61 graduates under this classification were pursuing occupations of diverse nature, such as those of physician, engineer, teacher of private school, governor, U.S. Army officer, general merchant, agent, librarian, clerk, councilor, metallurgist, foreman, actor, aviator, housewife, and nurse.

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[2] Experiment Station Record 68: 426–427.

Initial salary or earnings when first employed

The salaries or earnings of graduates when first employed are shown in table 5. There was a wide range, from a little less than ₱360 to over ₱1,800 a year. The median, however, was ₱960 for the 1911-15 graduates; ₱1,260 for 1916-20; ₱1,200 for 1921-25; and ₱1,215 for the 1926-30 alumni. The median initial salary had decreased to ₱625 by 1938 owing primarily to the economic depression. Another factor that contributed was the comparatively low scale of salaries paid to those in the extension service. To the salary of persons in this line of work should be added, however, the per diems, inasmuch as the municipal agricultural inspectors travel most of the time. Many of those engaged as farm managers were given free quarters and other privileges. Undoubtedly, many graduates accepted low pay at the start in order to get valuable experience.

The median initial salary of the graduates studied from 1911 to 1938 was ₱1,020 (table 5).

Salary or earnings in 1938

The 1938 salaries or earnings of graduates from their main occupations are shown in table 6. The older graduates, as should be expected, were receiving higher pay than the younger ones. The average for each group was: 1911-15, ₱4,421.27; 1916-20, ₱3,014.13; 1921-25, ₱1,970.22; 1926-30, ₱1,596.97; 1931-35, ₱1,223.91; and 1936-38, ₱902.33. The average for all the graduates was ₱1,623.97.

As may be seen in table 6, 40.1 per cent were receiving incomes from other sources. The percentage was greatly affected by the number of years that had elapsed since graduation, as shown by the higher proportion receiving secondary income among the older graduates. In the same table is also given the combined or total income of the graduates in 1938. The average, ₱1,984.85, is much higher than the ₱1,623.97 from the main occupation.

Land acquisition by graduates

The proportion of those that had acquired land ranged from 91.8 per cent in 1916-20 to 25.4 per cent in 1936-38, as may be seen in table 7. The average percentage for all graduates was 56.5.

The graduates acquired land in various ways: 30.4 per cent by purchase, 18.7 by inheritance, 4.8 by homestead, and 20.3 by purchase and inheritance (table 7). The others acquired their land holdings in two or more ways.

The area acquired did not exceed 20 hectares in 57.6 per cent of the cases as shown in table 8. The largest group, 24.6 per cent, owned land ranging from one-fourth to five hectares in size.

Place of business

As shown in table 9, only 22.3 per cent were pursuing their main occupations in their native towns and 20.9 per cent in other towns in their native provinces. The majority, 56.8 per cent, were pursuing their main businesses or occupations in other provinces.

Marital state

All the 1911-15 graduates included in the survey got married, but the percentage of the 1936-38 graduates who contracted marriage was only 24.3 (table 10). The percentage decreased steadily from 1911-15 to 1936-38. Of all the cases studied, 72.2 per cent were married by 1938.

Of those already married, 37.1 per cent contracted marriage within one year from graduation, 46.3 per cent within two years, 59.6 per cent within three years, and 80.3 per cent got married within five years. Only 3.6 per cent postponed marriage until ten years after date of graduation.

Home ownership

While 69.7 per cent of the 1916-20 graduates owned the houses in which they were living in 1938, only 27.0 per cent of the 1936-38 classes were owners of their dwellings (table 10). The average for all cases was 41.5 per cent.

SUMMARY

1. The graduates of the College of Agriculture, University of the Philippines were engaged in five groups of occupations in 1938: namely, educational work in agriculture, 37.0 per cent; technical work in agriculture, 29.2 per cent; farming or management of farms, 22.0; work slightly related to agriculture, 6.0; and work not related to agriculture, 5.8 per cent.

2. The initial salary of graduates when first employed was ₱1,020 a year on the average.

3. The salary or earnings in 1938 from the main occupation ranged from ₱4,421.27 for the 1911-15 graduates to ₱902.33 for the 1936-38, or an average of ₱1,623.97.

4. The percentage of graduates with secondary income was 40.1. The total income from all sources ranged from ₱4,616.32 for the 1911-15 graduates to ₱1,040.94 for the 1936-38, or an average of ₱1,984.85.

5. The proportion of graduates who owned land ranged from 91.8 per cent of the 1916-20 graduates to 25.4 per cent of the 1936-38 group, or an average of 56.5 per cent. The principal methods of acquiring land were by purchase, inheritance, or both. The area acquired was less than six hectares in 24.6 per cent of the cases studied.

6. More than half (56.8 per cent) of the graduates were pursuing their occupations outside their native provinces.

7. The proportion that had contracted marriage ranged from 100 per cent for the 1911-15 graduates to 24.3 per cent for the 1936-38 graduates, or 72.2 per cent for all cases studied.

8. Only 41.5 per cent were living in dwellings owned by themselves; 28.1 per cent were living in rented houses; and 23.3 per cent, in houses belonging to the employers.

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TABLE 1

Occupational groups in which graduates are engaged

OCCUPATIONS	NUMBER	PERCENTAGE
Educational work in agriculture, including administration of educational institutions	392	37.0
Technical work in agriculture, including administration of technical organizations	309	29.2
Farming or management of farm enterprises	233	22.0
Work slightly related to agriculture	63	6.0
Work not related to agriculture	61	5.8
Total	1,058	100.0

TABLE 2

Number engaged in educational work in agriculture [a]

OCCUPATIONS	1911-15	1916-20	1921-25	1926-30	1931-35	1936-38	TOTAL
Dean, College of Agriculture	1	—	—	—	—	—	1
College of Agriculture professors and instructors [b]	5	10	12	13	3	7	50
Science professors and instructors in other colleges	1	2	5	5	5	1	19
High school principals.	2	1	14	4	1	—	22
Supervisors of agricultural instruction, division industrial supervisors	—	1	3	1	1	—	6
Teachers of agriculture in agricultural and other high schools	2	9	30	28	49	29	147
Chief, assistant chief of agricultural extension; provincial and assistant provincial supervisors	1	7	9	8	21	4	50
Municipal agricultural inspectors	—	1	5	6	41	43	96
Home demonstrator	—	—	—	—	—	1	1
Total	12	31	78	65	121	85	392

[a] One alumnus was appointed president of the University of the Philippines soon after the survey was completed.

[b] Persons in this group devote certain portion of their time to research work.

TABLE 3

Number engaged in technical work in agriculture

OCCUPATIONS	1911-15	1916-20	1921-25	1926-30	1931-35	1936-38	TOTAL
Under-secretary of agriculture, director of Bureau of Plant Industry (P.I.)	1	1	—	—	—	—	2
Director of agriculture, director of experiment station (Siam)	—	—	1	—	1	—	2
Chiefs of divisions and sections, Bureau of Plant Industry	2	7	1	—	1	—	11
Station superintendents	3	6	1	—	1	—	11
Agronomists	2	13	24	12	25	5	81
Fiber inspectors, fiber experts	4	1	9	19	7	3	43
Tobacco inspectors, rice inspectors, agricultural and plant inspectors	—	2	2	3	1	—	8
Researchers, technical and laboratory assistants	2	3	6	7	13	3	34
Soil technologists, soil survey workers	—	—	—	4	3	3	10
Entomologists, ornithologists, fishery technologists	—	1	1	4	2	1	9
Plant pathologists, plant quarantine officers	—	—	1	2	2	—	5
Assistant superintendents, agriculturists in penal colonies	—	1	1	2	1	—	5
Chief, permit agents in Philippine Sugar Administration	—	—	1	4	7	1	13
Sugar chemists	—	1	6	14	18	4	43
Superintendents of sugar fabrication and of other sections in sugar centrals	3	2	1	1	1	—	8
Chemists in tikitiki, coconut, rice, cement, dairy firms, etc.	—	—	4	1	5	1	11
Starch factory, distillery superintendents	—	—	—	1	2	—	3
Ham factory manager	—	—	1	—	—	—	1
Animal husbandmen, livestock and meat inspectors	—	2	2	1	1	3	9
Total	17	40	62	75	91	24	309

TABLE 4

Number farming or managing farm enterprises

OCCUPATIONS	1911-15	1916-20	1921-25	1926-30	1931-35	1936-38	TOTAL
Farmers	8	30	21	21	28	6	114
Nurserymen, landscape gardeners	—	2	1	—	2	3	8
Livestock raisers, poultrymen	—	2	2	3	6	2	15
Ranch managers	—	—	—	1	4	—	5
Managers or administrators of family or private farms	2	2	8	13	34	14	73
Hacienda agronomists	—	1	5	9	3	—	18
Total	10	37	37	47	77	25	233

TABLE 5

Initial salary when first employed

SALARY RANGE	1911-15	1916-20	1921-25	1926-30	1931-35	1936-38	TOTAL
pesos							
Below 360	3	—	—	1	4	3	11
360 – 479	1	—	5	3	57	16	82
480 – 599	1	2	—	2	31	25	61
600 – 719	—	—	1	9	42	14	66
720 – 839	6	1	1	—	—	—	8
840 – 959	2	2	2	6	10	4	26
960 – 1,079	7	11	38	20	24	7	107
1,080 – 1,199	—	—	10	8	11	4	33
1,200 – 1,319	5	41	41	49	22	6	164
1,320 – 1,439	—	—	3	2	2	2	9
1,440 – 1,559	—	4	2	1	3	2	12
1,560 – 1,679	—	—	1	—	1	4	6
1,680 – 1,799	—	—	—	—	1	2	3
1,800 or over	—	7	8	8	1	3	27
Median	960	1,260	1,200	1,215	640	625	1,020

TABLE 6

Salary or earnings from principal and secondary occupations

YEAR	FROM PRINCIPAL OCCUPATIONS	FROM ALL SOURCES	PROPORTION WITH SECONDARY INCOME FROM OTHER SOURCES
	pesos	*pesos*	*per cent*
1911–15	4,421.27	4,616.32	65.0
1916–20	3,014.13	4,058.31	67.3
1921–25	1,970.22	2,258 95	64.1
1926–30	1,596.97	2,160.81	43.9
1931–35	1,223.91	1,353.18	33.7
1936–38	902.33	1,040.94	12.0
Average	1,623.97	1,984.85	40.1

TABLE 7

Methods of land acquisition

METHOD	1911-15	1916-20	1921-25	1926-30	1931-35	1936-38	TOTAL	PERCENTAGE
Purchase	8	21	42	27	16	1	115	30.4
Inheritance	2	2	10	10	35	12	71	18.7
Homestead	—	1	1	4	7	5	18	4.8
Purchase and inheritance	5	13	17	16	19	7	77	20.3
Inheritance and homestead	—	1	4	2	7	2	16	4.2
Purchase and homestead	2	6	8	5	3	1	25	6.6
Combination of purchase, inheritance, homestead, and other means	1	12	13	8	21	2	57	15.0
Percentage that acquired land	81.8	91.8	88.2	67.3	43.0	25.4	56.5	—

TABLE 8

Size of land acquired

AREA IN HECTARES	1911-15	1916-20	1921-25	1926-30	1931-35	1936-38	TOTAL	PER-CENT-AGE
1/4 – 5.........	2	11	21	20	33	6	93	24.6
6 – 10.........	2	9	19	15	24	7	76	20.1
11 – 20.........	2	6	15	12	11	3	49	12.9
21 – 30.........	—	6	13	6	18	6	49	12.9
31 – 40.........	3	3	6	4	11	1	28	7.4
41 – 50.........	2	5	7	4	6	1	25	6.6
51 – 75.........	—	2	3	3	2	—	10	2.6
76 – 100.........	2	4	10	5	3	1	25	6.6
Over 100.........	7	8	4	2	3	1	27	6.3
Total........	20	54	98	71	110	26	379	100.0

TABLE 9

Place of business

CLASSES	IN HOME TOWN	IN HOME PROVINCE	IN OTHER PROVINCES
1911–15	34.6	23.1	42.3
1916–20	27.3	13.6	59.1
1921–25	27.9	17.1	55.0
1926–30	20.5	15.4	64.1
1931–35	19.3	21.3	59.4
1936–38	19.0	33.6	47.4
Total	22.3	20.9	56.8

TABLE 10

Marital state and home ownership

CLASSES	MARRIED	RESIDENCE					
		Rented	Owned by employers	Owned by relatives	Their own	Total	Owning their homes
	per cent						*per cent*
1911–15	100.0	3	6	2	16	27	59.3
1916–20	95.8	13	5	2	46	66	69.7
1921–25	94.8	17	39	3	66	125	52.8
1926–30	87.1	26	33	4	49	112	43.8
1931–35	66.3	81	62	24	79	246	32.1
1936–38	24.3	54	16	14	31	115	27.0
Total	72.2	194	161	49	287	691	41.5
Percentage	—	28.1	23.3	7.1	41.5	100.0	—

A STUDY OF THE YIELD OF CASSAVA AS AFFECTED BY THE AGE OF CUTTINGS[1]

ANGEL S. HUERTAS

What portion of the cassava stem is best for planting has not been determined. Most planters ordinarily use for planting all available cuttings irrespective of age.[2] As mature cuttings may differ in yield from the young ones, it is necessary to know definitely which of these will give a larger amount of storage roots and starch. Hence, this study was conducted.

Review of literature

Guanzon (1927) pointed out that any part of the cassava stem may be used for propagation, including the stumps, but the best part is the mature portion of the stem with the exception of that nearest the root and the green portion at the end. Mendiola (1931) stated that, in planting cassava, the young top portion is removed while the remaining part is cut into pieces and used for planting. The bottom pieces seem to be better than the upper cuttings as planting materials.

Galang (1931) reported that the average yield of roots per hectare of base cuttings obtained in a trial planting was 36.50 tons; of middle cuttings, 34.94 tons; and of apical cuttings, 19.17 tons. From these results he suggested the use of the base and middle portions of the stem for planting.

Object of the present work

The main object of the present work was to determine the relative production of storage roots and starch under commercial field planting from different cuttings of seventeen-month old cassava plants.

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[1] Experiment Station contribution No. 1345. Prepared in the Department of Agronomy under the direction of Professor N. B. Mendiola and Mr. T. Mercado.

[2] "Age" in this article refers to the relative degree of maturity of the different portions of the stem, with the apical cutting considered as the youngest; the cuttings following it to the base of the stem, as increasing in maturity; and the basal cuttings, the oldest.

Time and place of the work

The work was conducted from December 1, 1936, to February 19, 1938. Planting was performed in a section of the Experiment Station grounds of the College of Agriculture, University of the Philippines, at Los Baños, Laguna. Extraction of starch was done in the College starch factory and the laboratory of the Plant Breeding Division of the Department of Agronomy of this College.

MATERIALS AND METHODS

Land

The field used in this experiment is trapezoidal in form, fairly level, and has an area of 8,135 square meters. The soil is clay loam. This land had been previously planted to cassava.

Variety used

For this study, the variety used was Zaailing No. 3718. It is one of the commercial varieties of cassava brought by Dr. N. B. Mendiola from Java in 1927 to this College. It had given an average yield of forty-one tons of storage roots per hectare (Sicam, 1931).[3]

Sicam (1931) gives the following data for this variety: percentage of germination, 63.3 per cent; height at age of six months, 55.13 cm.; yield of storage roots per hill, 5.28 kgm.; computed yield of storage roots per hectare, 41,129 kgm.; yield of starch per hectare, 4,676 kgm.; percentage of starch, 11.35 per cent; hydrocyanic acid content of peeled portion of roots, 0.03 per cent; taste, medium; palatability, unpleasant; texture of boiled roots, hard; and fiber content of roots, not fibrous.

Preparation of the field

The field was first plowed with a disc plow drawn by a tractor. The next plowing was done with a native plow drawn by an animal. Harrowing took place on the same date. Then the field was plowed again with animal drawn plows two weeks later. It was immediately followed by harrowing, after which the field was planted.

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[3] Sicam, H. P. Comparative test of eighteen varieties of cassava in the College of Agriculture. (Thesis presented for graduation from the College of Agriculture with the degree of Bachelor of Agriculture. 1931. Unpublished.)

Cuttings used

The cassava stalks used for planting were taken from a seventeen-month old cassava field.

Cassava stems which were about 255 centimeters long and without branches were selected and cut close to the ground. These were separated into different groups of cuttings and planted the same day. Nine cuttings, 25 centimeters long each, were cut from each stalk. There were about 15 buds on each cutting.

From the youngest apical portion of the stem to its base, the cuttings obtained were numbered consecutively from one to nine; that is, the uppermost or youngest was labelled No. 1; the one immediately below it, No. 2; the third, No. 3; etc. The last or oldest cutting at the base was labelled No. 9. All cuttings taken from the same section of the stems and, therefore, possessing the same degree of maturity were put together and considered as one group of cuttings.

Cuttings designated Nos. 1, 2, and 3 may be considered as top or young cuttings; Nos. 4, 5, and 6, middle cuttings; and Nos. 7, 8, and 9, base, or old cuttings.

Method of planting

The field was first divided into nine plots. The first nine rows constituted the first plot, where all the nine groups of cuttings were planted separately. That is, the first row was planted to group No. 1, the second row, group No. 2, and so on until the ninth row, which was planted to group No. 9. The same method was followed in planting the other eight plots in the same field. Each group of cuttings was replicated nine times.

The cuttings were planted 75 centimeters apart in rows distanced one meter. Only one cutting was inserted in each hill, planted at an angle of about thirty degrees, and covered with soil.

Care of the culture

The entire culture was given the same care and treatment from planting to harvesting. The field was first cultivated when the plants were about two months old. Off-barring was made by passing a "Calamba" cultivator between the rows. This was followed by weeding the rows with hoes, or by hand when the weeds were close to the plants. Two months after off-barring, or when the plants were about 50 centimeters tall, they were hilled-up. Whenever necessary, weeds were cut down with sickles.

Harvesting

The roots were harvested when the plants were twelve months old. Before being dug up, the stems were first cut off close to the ground and piled in places away from the path of the plow. The roots were dug up with a J. A. Black Lead Moldboard two-handled plow, drawn by two bullocks. One man handled the plow and the other man the animals. Another man picked up the roots and piled them where they would not be covered with the soil of subsequent plowings.

Each row was plowed three times. The first two passages were made on both sides of each row, one foot from the stems, and the third, through the center of the row.

Fresh roots from each row were hauled to the College starch factory where the starch extraction was done with the Cuzner grater.

Field observations

Germination. The germination or sprouting of the buds from the planted cuttings was observed four months after planting. This was done because not all the cuttings germinated at the same time.

Percentage of stand.[4] Before the crop was harvested, the number of hills that reached maturity were counted and recorded. The percentage of stand was then determined.

Length of stems at maturity. The length of the stems from each group of cuttings was measured before harvesting. A total of 100 stalks from each group was measured. A stalk was measured from each hill with a meter stick from the base to the node of the first open leaf.

Number of stalks per hill. Before harvesting, the number of stalks from each group of cuttings in each plot was counted. The average number of stalks per hill from each group of cuttings was determined.

Yield of roots and starch

The total weight of fresh storage roots harvested from every group of cuttings from each plot was obtained and the yield of roots per hill and per hectare was determined from them.

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[4] "Stand" refers to the number of hills which reached maturity.

From the weight of the starch produced from each group of cuttings grown in each plot, the yield per hill as well as per hectare was computed.

The percentage of starch was determined from the weight of dried starch extracted from each group of cuttings harvested from each plot.

RESULTS AND DISCUSSION

Percentage of germination

As shown in column 2 of table 1, the group of cuttings that gave the highest percentage of germination was No. 9, which was composed of the oldest cuttings. It can be seen further from this table that the percentage of germination can be divided into three groups: namely, the 82 per cent group to which Nos. 6, 7, 8, and 9 belong; the 74 – 77 per cent group under which Nos. 4 and 5 fall; and the last group, below 63 per cent, to which Nos. 1, 2, and 3 belong.

When the percentages of germination of these different groups of relatively varying maturity were compared, only the difference between No. 1 and No. 9 was found significant. It was observed that the buds from the older cuttings sprouted earlier than those from the younger ones. It was further noted that cuttings obtained about 75 centimeters below the apex apparently gave low percentages of germination under conditions existing in this study.

Average percentage of stand

Not all of the cuttings that germinated reached maturity. Column 3 of table 1 shows the percentages of stand from the various cuttings which reached maturity. The oldest cuttings (No. 9) gave the highest percentage of stand whereas the youngest gave the lowest. The difference in the percentage of stand between Nos. 1 and 2 and No. 9 is significant. When the percentages of stand of the other groups or cuttings were compared with that of No. 9, no significant differences were found. The percentage of stand ranged from 78.9 to 82.3 per cent for Nos. 6, 7, 8, and 9; 73.7 to 76.0 per cent for Nos. 4 and 5; and 63.0 per cent or below for Nos. 1, 2, and 3.

Length of stalks at maturity

In column 4 of table 1 the average length of stalks at maturity is shown. It ranges from 219.6 ± 1.8 cm. to 240.7 ± 2.1 cm. By comparing the average lengths of stalks from the different groups with that of No. 3 which yielded the longest stalks, significant differences were noted for groups Nos. 1, 2, and 5. Other differences were found insignificant.

Number of stalks

The number of stalks per hill from the various groups of cuttings was found to be practically the same (column 5, table 1). The highest average number of stalks per hill was obtained from No. 9. The lowest average number of stalks was found from group No. 1. With No. 9 as a basis for comparison, all differences in the average number of stalks per hill were found insignificant, clearly indicating that the number of stalks developing from cuttings obtained from any portion of the stems of cassava does not vary much.

Yield of roots

Yield of roots per hill. As shown in table 2, cuttings of group No. 2 yielded 2.9 ± 0.47 kgm. of fresh roots per hill, which is the highest weight of roots produced. Group No. 6 gave the lowest yield being 1.7 ± 0.15 kgm. When the average yields of roots per hill from the different groups were compared with the highest yield from No. 2 as the basis, no significant differences were found. Here again the yield of storage roots per hill seems not to be dependent on the age of cuttings used under conditions obtaining in this study.

Yield of roots per hectare. The oldest cuttings (No. 9) produced the highest yield (21.4 ± 3.07 tons) of roots per hectare. The youngest group (No. 1) gave the lowest yield, 4.4 ± 1.58 tons. When the computed yields of roots per hectare of the different groups of cuttings were compared with the highest yield obtained from No. 9, it was found that only the difference between No. 1 and No. 9 was significant. This fact shows that although the youngest cuttings gave a higher average weight of storage roots per hill, they did not give a correspondingly higher yield of storage roots per hectare.

Yield of starch

Percentage of starch. It is interesting to note that the percentage of starch obtained from roots harvested from the different groups of cuttings decreased with the increase in age (table 3). The youngest cuttings gave the highest percentage of starch extracted. The difference between No. 1 and No. 9 was 2.29 ± 0.61 per cent.

Yield of starch per hill. The highest yield of starch per hill was obtained from Nos. 1 and 2 groups of cuttings. It can be seen in table 3 that Nos. 1 and 2 yielded 0.3 kgm. each per hill, while the rest gave only 0.2 kgm. each. The differences in the quantity of starch produced from the different groups of cuttings were found insignificant.

Yield of starch per hectare. Group No. 9 excelled the rest in the yield of starch per hectare. No. 1 gave the lowest yield. Except for the yield of No. 1, the differences between the yields were found to be insignificant. From the results herein presented, it seems that the greater benefits could be derived from cuttings below 75 centimeters from the apex of the stem of cassava as claimed by several investigators such as Mendiola (1931) and Galang (1931).

SUMMARY AND CONCLUSIONS

1. The percentages of germination from base or old cuttings Nos. 6 to 9 were the highest, whereas middle cuttings Nos. 4 to 5, respectively, were next. The lowest percentages of germination were obtained from the young or top cuttings Nos. 1 to 3 inclusive.
2. The old cuttings gave higher percentages of stand than the young ones. Insignificant differences were found in number of stalks per hill produced by the base, middle, and the top cuttings.
3. The old cuttings gave significantly higher yield of roots per hectare than the young cuttings.
4. The medium and old cuttings, those in groups 3 to 9, exceeded the younger ones (groups 1 to 2) in the yield of starch per hectare. A significant difference was found between the yields of starch per hectare of the oldest cuttings and the youngest ones.
5. The percentages of starch obtained from roots harvested from young cuttings were higher than those from old ones.

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MENDIOLA, N. B. 1931. Cassava growing and cassava starch manufacture. The Philippine Agriculturist. **20**: 447–476. *Fig. 1–12.*

TABLE 1

Percentage of germination and stand, average length, and number of stalks per hill at maturity

GROUP OF CUTTINGS	GERMINATION	STAND	AV. LENGTH OF STALKS AT MATURITY	AV. NUMBER OF STALKS PER HILL
	per cent	*per cent*	*cm.*	
1	15.1 ± 4.6	13.2 ± 4.8	219.6 ± 1.8	1.0 ± 0.05
2	45.2 ± 12.4	44.0 ± 12.8	227.8 ± 1.7	1.3 ± 0.10
3	63.9 ± 17.5	62.9 ± 7.4	240.7 ± 2.1	1.3 ± 0.22
4	74.1 ± 4.6	73.7 ± 6.9	234.5 ± 2.0	1.3 ± 0.09
5	77.0 ± 3.4	76.0 ± 3.9	229.9 ± 2.1	1.3 ± 0.11
6	82.4 ± 2.4	82.0 ± 2.5	236.8 ± 1.4	1.4 ± 0.24
7	82.1 ± 2.1	79.9 ± 3.7	233.0 ± 2.1	1.3 ± 0.18
8	82.5 ± 1.5	78.9 ± 3.7	232.2 ± 1.9	1.4 ± 0.23
9	82.7 ± 3.9	82.3 ± 1.5	235.4 ± 1.6	1.4 ± 0.23

TABLE 2

Yield of storage roots per hill and per hectare

GROUP OF CUTTINGS	AVERAGE YIELD PER HILL	COMPUTED YIELD PER HECTARE
	kgm.	*tons*
1	2.5 ± 0.35	4.4 ± 1.58
2	2.9 ± 0.47	15.6 ± 2.79
3	2.3 ± 0.41	19.6 ± 1.12
4	1.8 ± 0.10	18.2 ± 1.70
5	1.9 ± 0.24	19.7 ± 1.70
6	1.7 ± 0.15	19.2 ± 0.94
7	1.8 ± 0.20	19.4 ± 2.02
8	1.9 ± 0.20	18.5 ± 1.25
9	1.9 ± 0.29	21.4 ± 3.07

TABLE 3

Dry starch produced per hill and per hectare

GROUP OF CUTTINGS	PER CENT OF STARCH EXTRACTED	STARCH PRODUCED	
		Per hill	Per hectare
		kgm.	*tons*
1	13.2 ± 0.6	0.3 ± 0.07	0.57 ± 0.29
2	11.5 ± 0.2	0.3 ± 0.12	1.81 ± 0.29
3	11.6 ± 0.2	0.3 ± 0.16	2.25 ± 0.41
4	12.3 ± 0.2	0.2 ± 0.04	2.21 ± 0.42
5	10.7 ± 0.1	0.2 ± 0.09	2.12 ± 0.50
6	10.9 ± 0.1	0.2 ± 0.11	2.07 ± 0.20
7	10.4 ± 0.1	0.2 ± 0.57	2.02 ± 0.16
8	10.7 ± 0.2	0.2 ± 0.04	2.01 ± 0.30
9	10.9 ± 0.04	0.2 ± 0.02	2.31 ± 0.34

OBSERVATIONS ON THE CAPACITY AND MEASUREMENTS OF THE ALIMENTARY TRACT OF NATIVE CARABAOS [1]

FERNANDO C. RICERRA

The objects of this work were to secure data on the capacity and measurements of the different parts of the alimentary tract, including the weight of contents of the compartments of the compound stomach of the native carabao.

The work was conducted in the Department of Animal Husbandry, and in the municipal abattoir at Tuguegarao, Cagayan, from November, 1932, to June, 1934, covering a period of one year and seven months.

MATERIALS

Animals. Twenty mature native carabaos were used, ten males and ten females. On the average, the age of the males was 12.3 years, the weight 524.1 kgm., the height 140.4 cm., and the length of body 153.8 cm. In the females, on the average, the age was 14.6 years, the weight 508.4 kgm., the height 136.8 cm., and the length of body 145.6 cm. (table 1).

Equipment. For measuring and weighing the living animals, a measuring stick, ribbon tape, and a portable Fairbanks scale of 1,000 kilograms capacity were used. For measuring the capacity of the digestive tract, calibrated empty kerosene cans and graduated glass cylinders were employed. To determine the length and width of the different parts of the alimentary tract, the ribbon tape was used.

METHODS

Determination of age and health of the animals. The age of the animals was obtained by examining the certificate of ownership of each. Inasmuch as the animals used belonged to farmers owning only a few head, the age indicated in the certificate of ownership was considered to be fairly reliable.

All the animals were in good health. Before slaughter they were deprived of feed and water for a period of approximately six hours.

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[1] Experiment Station contribution No. 1346. Prepared in the Department of Animal Husbandry under the direction of Associate Professor Valente Villegas.

Weight and measurements of living animals. Living carabaos were weighed and measured one or two days before they were slaughtered. The weight was obtained by making the animal step on a piece of board mounted on the scale. In the case of six of the animals which were vicious, the weights were taken immediately after they were killed.

Height. The height was taken at the withers.

Length of body. The length of body was determined by taking the distance from the point of the shoulder to the pin bone.

Capacity and measurement of the alimentary tract. The capacity and measurements of the following parts of the alimentary tract were made at the time of dressing the carcass or soon after, and in all cases before *rigor mortis* had set in. The weights of the contents of the different stomach compartments were also obtained.

Mouth. The width of the tongue was taken at the base, at the middle, and at a point close to the tip. Measurements were made of the upper jaw. Its length, from the posterior border of the soft palate to the anterior border of the dental pad, was taken. The width was taken at three points; namely, at the last pair of the molars, at the first pair of the pre-molars, and at the anterior border of the premaxillae.

Oesophagus. The outside circumference of the oesophagus was measured at four places and the average was taken as the true measurement. Its length, from the pharynx to the rumen, was determined.

Rumen, reticulum, omasum, abomasum. To determine the capacity of each of the stomach compartments, the contents were first removed and the compartments thoroughly flushed with water. Water was afterwards placed in each compartment, the volume of the former being taken as the capacity of the compartment under study. The weights of the contents of the different compartments were also taken.

Intestines. In the case of the small and large intestines, the contents were also emptied before cleaning. The capacity was determined in the same manner as in the compound stomach. The length and width were also obtained. Measurements on width were made at various places, the average being taken as the true measurement.

Caecum, rectum. Separate determinations were also made of the capacity, length, and width of the caecum and rectum.

DISCUSSION OF RESULTS

Table 2 shows the capacity and measurements of the different parts of the alimentary canal. The weights of contents of the compound stomach are also given in this table.

Mouth

The average measurements of the tongue in the male carabaos were as follows: length, 37.58 cm.; width at the base, 8.02 cm.; width at the tip, 7.51 cm.; width at the middle, 8.25 cm. In the females, length, 38.54 cm.; width at the base, 8.28 cm.; width at the tip, 7.56 cm.; width at the middle, 8.34 cm.

The average measurements of the upper jaw in the males were as follows: length, 30.41 cm.; width at the base, 13.74 cm.; width at the tip, 12.35 cm.; width at the middle, 11.60 cm. In the females, they were: length, 30.52 cm.; width at the base, 13.29 cm.; width at the tip, 12.43 cm.; width at the middle, 11.47 cm.

Oesophagus

In the males, the average measurements of the oesophagus were: length 100.70 cm., width 5.88 cm.; in the females, length 99.65 cm., width 5.66 cm.

Rumen

In the males, the average capacity of the rumen was 71.16 liters, the contents weighing on an average of 36.41 kgm. In the females, the average capacity was 70.13 liters, the weight of the contents being on an average, 39.58 kgm. The average measurements of the rumen in the males were: length 87.60 cm., width 79.36 cm.; in the females, length 86.70 cm., width 78.40 cm.

Reticulum

The average capacity of the reticulum in the males was 3.20 liters, the contents weighing on an average of 1.21 kgm. In the females, the average capacity was 2.97 liters, the average weight of the contents being 1.18 kgm. The average measurements of the reticulum in the males were: length 30.07 cm., width, 16.20 cm.; in the females, length 29.90 cm., width 15.30 cm.

Omasum

In the males, the average capacity of the omasum was 5.33 liters, the contents weighing on an average of 5.28 kgm. In the females, the capacity was on an average of 5.31 liters, the average weight of the contents being 5.20 kgm. The average measurements of the omasum in the males were: length 28.20 cm., width 25.75 cm.; in the females, length 27.65 cm., width 25.65 cm.

Abomasum

The average capacity of the abomasum in the males was 9.09 liters, its contents weighing on an average of 1.09 kgm. In the females, the capacity was on an average of 8.85 liters, the contents weighing on an average of 1.05 kgm. The average measurements of the abomasum in the males were: length 52.70 cm., width 21.45 cm.; in the females, length 51.60 cm., width 20.50 cm.

Small intestine

The average capacity of the small intestine in the males was 23.05 liters and in the females, 21.09 liters. The average measurements in the males were: length 25.68 m., width 5.71 cm.; in the females, length 23.25 m., width 5.54 cm.

Large intestine

The large intestine had an average capacity of 15.96 liters in the males and 16.26 liters in the females. The average measurements in the males follow: length 9.49 m., width 8.44 cm.; in the females, length 9.04 m., width 8.20 cm.

Caecum

The average capacity of the caecum in the males was 3.57 liters and in the females, 3.63 liters. On an average, its measurements in the males were: length 35.50 cm., width 12.05 cm.; in the females, length 35.65 cm., width 11.75 cm.

Rectum

The rectum had an average capacity of 3.95 liters in the males and 3.98 liters in the females. The average measurements in the males were as follows: length 42.20 cm., width 11.96 cm.; in the females, length 41.40 cm., width 11.65 cm.

The aggregate capacity of the compound stomach, small and large intestines, caecum and rectum in male carabaos ranged from 115.9 to 153.9 liters, the average being 135.97 liters. In the females, it varied from 129.3 to 160.4 liters, the average being slightly lower than in the males amounting to 131.21 liters. The average capacity in both males and females was 133.59 liters.

It is evident from the above data that the difference between the capacity and measurements of the alimentary canal of the males and of the females was slight and, in general, was in favor of the males.

Manresa and Villegas[2] found that the total capacity of the compound stomach of an Indian buffalo cow was 113 liters; that of the small intestine, 28.22 liters; large intestine, including the caecum and rectum, 28.4 liters; caecum, 3.54 liters; rectum, 5.0 liters. The length of the small intestine was 2,570 cm.; large intestine, including the caecum and rectum, 1,002 cm.; caecum, 33.0 cm.; rectum, 75.0 cm.

SUMMARY AND CONCLUSIONS

Studies on the capacity and measurements of the alimentary canal of the male and female native carabaos gave the following average results:

1. Tongue: length, 38.06 cm.; width at the base, 8.15 cm.; width at the tip, 7.54 cm.; width at the middle, 8.30 cm. Upper jaw: length, 30.47 cm.; width at the base, 13.52 cm.; width at the tip, 12.39 cm.; width at the middle, 11.54 cm.

2. Oesophagus: length, 100.18 cm.; width, 5.77 cm.

3. The capacity of the compound stomach was 88.03 liters distributed as follows: rumen, 70.65 liters, reticulum, 3.09 liters; omasum, 5.32 liters; abomasum, 8.97 liters.

4. The capacity of the small intestine was 22.07 liters; large intestine, 16.11 liters; caecum, 3.60 liters; rectum, 3.96 liters.

5. The aggregate capacity of the compound stomach, small and large intestines, caecum, and rectum was 133.59 liters.

6. The weights of contents of the rumen was 38.00 kgm.; reticulum, 1.20 kgm.; omasum, 5.24 kgm.; abomasum, 1.07 kgm.

7. The measurements of the compound stomach were: Rumen—length, 87.15 cm.; width, 78.88 cm. Reticulum—length, 30.00 cm.; width, 15.75 cm. Omasum—length, 27.88 cm.; width, 25.70 cm. Abomasum—length, 52.15 cm.; width, 20.98 cm.

8. The measurements of the small and large intestines, caecum, and rectum were: Small intestine—length, 24.47 m.; width, 5.63 cm. Large intestine—length, 9.27 m.; width, 8.32 cm. Caecum—length, 35.58 cm.; width, 11.90 cm. Rectum—length, 41.80 cm.; width, 11.81 cm.

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[2] MANRESA, MIGUEL, AND VALENTE VILLEGAS. 1930. A note on the capacity and other measurements of the alimentary tract of an Indian buffalo cow. The Philippine Agriculturist 18: 605–607.

TABLE 1

Age, weight, and measurements of Philippine carabaos

MALES

ANIMAL NUMBER	AGE	WEIGHT	HEIGHT	LENGTH OF BODY
	years	*kgm.*	*cm.*	*cm.*
1	9	484	136.0	168.0
2	9	509	137.5	135.0
3	9	623	152.4	157.0
4	10	548	143.5	157.0
5	10	591	147.0	168.0
6	13	566	144.0	147.0
7	14	512	140.0	147.0
8	14	451	135.0	139.0
9	16	480	135.5	152.0
10	19	477	134.0	168.0
Average	12.3	524.1	140.4	153.8

FEMALES

ANIMAL NUMBER	AGE	WEIGHT	HEIGHT	LENGTH OF BODY
11	8	510	138.5	152.0
12	9	669	153.5	167.0
13	11	574	138.0	157.5
14	13	495	130.0	133.0
15	14	526	142.0	152.0
16	15	389	124.0	132.0
17	17	446	127.0	137.0
18	18	468	139.0	134.0
19	20	471	133.2	135.0
20	21	536	142.5	157.0
Average	14.6	508.4	136.8	145.6

TABLE 2

The capacity and measurements of the different parts of the alimentary tract of Philippine carabaos

PARTS OF THE ALIMENTARY CANAL		MALE		FEMALE		AVERAGE FOR MALE AND FEMALE CARABAOS
		Range	Average	Range	Average	
Mouth						
(a) Tongue						
Length, tip to base	*cm.*	32.4– 40.0	37.58	37.1– 41.1	38.54	38.06
Width at base	*cm.*	7.4– 8.7	8.02	7.7– 8.7	8.28	8.15
Width near tip	*cm.*	6.9– 8.2	7.51	7.0– 8.3	7.56	7.54
Width at middle	*cm.*	7.4– 8.8	8.25	7.8– 9.0	8.34	8.30
(b) Upper jaw						
Length, tip to base	*cm.*	29.7– 31.6	30.41	29.6– 31.5	30.52	30.47
Width at base	*cm.*	13.0– 14.8	13.74	12.2– 14.0	13.29	13.52
Width near tip	*cm.*	11.6– 13.1	12.35	11.5– 13.0	12.43	12.39
Width at middle	*cm.*	10.5– 12.5	11.60	10.5– 12.1	11.47	11.54
Oesophagus						
Length	*cm.*	94.0–106.0	100.70	91.0–107.0	99.65	100.18
Width	*cm.*	5.1– 6.5	5.88	5.0– 6.0	5.66	5.77
Rumen						
Length	*cm.*	79.0– 95.0	87.69	75.0– 96.0	86.70	87.15
Width	*cm.*	75.0– 85.0	79.36	74.0– 87.0	78.40	78.88
Capacity	*liters*	53.4– 88.5	71.16	49.2– 89.0	70.13	70.65
Weight of content	*kgm.*	31.0– 42.3	36.41	31.2– 47.2	39.58	38.00
Reticulum						
Length	*cm.*	24.0– 35.0	30.07	24.0– 43.0	29.90	30.00
Width	*cm.*	13.0– 19.0	16.20	12.0– 20.0	15.30	15.75
Capacity	*liters*	1.9– 4.1	3.20	2.2– 4.2	2.97	3.09
Weight of content	*kgm.*	1.1– 1.3	1.21	0.7– 1.5	1.18	1.20

TABLE 2 (continued)

PARTS OF THE ALIMENTARY CANAL		MALE		FEMALE		AVERAGE FOR MALE AND FEMALE CARABAOS
		Range	Average	Range	Average	
Omasum						
Length	*cm.*	26.0– 33.5	28.20	26.0– 30.0	27.55	27.88
Width	*cm.*	23.5– 27.5	25.75	23.0– 27.5	25.65	25.70
Capacity	*liters*	4.8– 5.7	5.33	4.8– 6.1	5.31	5.32
Weight of content	*kgm.*	5.1– 5.5	5.28	5.0– 5.5	5.20	5.24
Abomasum						
Length	*cm.*	47.0– 59.0	52.70	47.0– 54.0	51.60	52.15
Width	*cm.*	18.0– 24.0	21.45	19.0– 22.0	20.50	20.98
Capacity	*liters*	7.3– 10.5	9.09	7.3– 9.7	8.85	8.97
Weight of content	*kgm.*	0.9– 1.3	1.09	0.8– 1.3	1.05	1.07
Small intestine						
Length	*m.*	19.5– 28.7	25.68	19.4– 28.6	23.25	24.47
Width	*cm.*	5.3– 6.0	5.71	5.1– 6.0	5.54	5.63
Capacity	*liters*	17.3– 27.5	23.05	17.1– 26.2	21.09	22.07
Large intestine						
Length	*m.*	8.7– 10.0	9.49	7.0– 10.5	9.04	9.27
Width	*cm.*	8.0– 8.8	8.44	7.4– 8.8	8.20	8.32
Capacity	*liters*	14.6– 17.5	15.96	14.5– 18.2	16.26	16.11
Caecum						
Length	*cm.*	30.0– 42.0	35.50	32.0– 39.0	35.65	35.58
Width	*cm.*	10.5– 13.5	12.05	10.0– 14.0	11.75	11.90
Capacity	*liters*	2.6– 4.6	3.57	3.1– 4.1	3.63	3.60
Rectum						
Length	*cm.*	35.0– 49.0	42.20	34.0– 48.0	41.40	41.80
Width	*cm.*	10.0– 13.5	11.96	9.5– 14.0	11.65	11.81
Capacity	*liters*	3.2– 5.0	3.95	3.0– 4.7	3.98	3.96
Total capacity	*liters*	115.9–153.9	135.97	129.3–160.4	131.21	133.59

COLLEGE AND ALUMNI NOTES

From Secretary Jorge B. Vargas, President of the University of the Philippines Alumni Association, the College received at the Buenavista Estate 45 panicles of Quezon rice, from which 100 grams of seed was secured. One-half of the seed was planted immediately by the Department of Agronomy and the other half is being saved for the next regular lowland rice planting season.

President and Mrs. B. M. Gonzalez were hosts to the faculty of the College at the traditional New Years' eve hall at Molawin Hall. As part of the merry-making, various competitive groups featured special dance numbers. The group under the leadership of Drs. F. O. Santos and Leon Gonzalez, featuring waltz numbers with variations, was adjudged the winner of the prize donated by the hosts.

The faculty and employees of the College gave, as usual, the annual Christmas luncheon for students of the College on December 23. After the luncheon, the students participated in a free raffle in which fairly substantial prizes were at stake. These prizes were donations by some members of the faculty and by tradespeople of Los Baños.

A Christmas program, sponsored by the student body of the College and presented on the evening of December 15, consisted of musical numbers, recitations, and a playlet, *Lost: One Christmas Day* written and directed by Mr. M. V. Arnaldo.

Among the senior students of the University elected to membership in the Honor Society of Phi Kappa Phi, University of the Philippines Chapter, at its meeting on December 15, were the following senior students of the College:

José R. Velasco
Alfonso B. Castro
Felipe A. Maclang
Florendo R. Naanep
Valentin G. Cedillo
Davi Yanasugondha
(Miss) Fidela Ilag

At a meeting of the Society for the Advancement of Research on December 14, the following were elected to membership:

Active members:	*Associate members:*
Dr. Arcadio C. Gonzaga	Florendo R. Naanep
Mr. Justino Seguerra	Crisostomo E. Liongson
	José R. Velasco

Professor Vicente B. Aragon took 51 students enrolled in Agronomy 13 on a trip to the Central Luzon provinces during the period, December 16-19, inclusive. Visits were made to rice fields of the Central Luzon Agricultural School at Muñoz, rice mills and warehouses at Cabanatuan, offices of the Naric, and irrigation systems at Angat, Bulacan and San José, Nueva Ecija.

Students enrolled in Agronomy 15 and 16 under Dr. Pedro David went on a full week's trip to the Bicol provinces from December 16 to 23, inclusive. Among the principal places visited by them were the Agusan coconut plantation at San Miguel Island, Tabaco, Albay, the Fiber Inspection Service at Legaspi, grading and baling establishments also at Legaspi, and private coconut and abaca plantations in Camarines Sur and Sorsogon.

Dr. Pablo N. Mabbun, assistant professor of agricultural economics, left the campus on January 2 to serve on detail with the College of Business Administration, Manila.

THE RÔLE OF THE SUBSISTENCE FARMSTEAD IN RURAL RECONSTRUCTION [1]

FRANCISCO M. SACAY
Of the Department of Agricultural Education

WITH THREE TEXT FIGURES

The Philippines is predominantly an agricultural country, with a major portion of the population living in farm villages. In our program of nation building, we should, therefore, give the rural communities and the rural dwellers adequate attention, commensurate with their importance in our national life.

That conditions in rural districts are far from satisfactory is evidenced by the desire of youth to leave the farm and migrate to the city, the agrarian troubles that occur frequently, the poor economic condition of the farm family, and the insufficient conveniences and inadequate social facilities in rural communities.

THE RURAL PROBLEMS

The important problems in our rural districts may be grouped under the following categories: (1) health, (2) economic, (3) educational, (4) civic, (5) recreational, (6) communication, and (7) aesthetic. No attempt will be made to discuss the various problems in detail. Only those apparent even to the casual observer will be considered briefly.

Health problems

The rural people are not properly nourished. Their food is often deficient in quantity and quality. In many cases, the house and its surrounding are not sanitary. Wastes are not disposed of properly, and there is no good source of safe drinking water. Proper medical facilities are inadequate. Many people are ignorant of the causes and prevention of common diseases.

Economic problems

The income of the average farmer is low. This is the result of small-sized farms, one-crop system of farming, and low productive efficiency. The farmer is often the victim of unscrupulous middle-

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[1] General contribution from the College of Agriculture No. 722.

THE PHILIPPINE AGRICULTURIST, VOL. XXVIII, No. 10, MARCH, 1940.

men, store keepers, and money lenders. As a result of his poor financial condition, he cannot afford the prime necessities of life—proper food, clothing, and shelter, much less adequate schooling, medical attention, healthful recreation, comforts, and conveniences.

Educational problems

Because of the poor financial status of the farm family, a large proportion of the children do not even see the inside of a schoolhouse. The majority of those that start schooling do not stay long enough to acquire ability to read and write intelligently. They cannot make use of the printed page in acquainting themselves with happenings here and abroad. Various governmental agencies created to carry out the task of uplifting the masses make slow progress because they cannot effectively use the printed page in communicating their ideas to the people. Because of ignorance, the people are guided in their daily activities by superstitions rather than by tested knowledge.

Civic problems

The ignorance of the people make them inefficient in governmental participation. They do not know the plans and policies of the government. Very often they follow wrong leadership largely because it is the only kind available. As a result, serious disturbances occur in which these poor ignorant folk are often the victims.

Recreational problems

The rural dwellers usually have to go to the towns and cities where movies, theaters, libraries, playgrounds, and other recreational centers are found. There are certain parts of the year when farm people have a large amount of free time. Cock-fighting and gambling attract many of them. The farm people, both young and old, should be encouraged to engage in better forms of recreation, such as athletics, games, dramatics, and reading.

Communication

The poor transportation facilities in rural districts isolate the people from centers of progress. The children find it difficult to attend school. The young and adult are not encouraged to participate in social, civic, and recreational activities with people living in other districts. Governmental agencies, such as doctors, nurses, dentists, adult teachers, and agricultural advisers, reach the rural villages with great difficulty. Many communities do not have regular mail facilities. New ideas do not easily filter into these districts, making changes toward improvement difficult and slow.

Aesthetic problems

Our poets sing of the beauty of the country. But as one travels in rural communities, he will not fail to notice the unsightly houses that need repair, the dirty yards, weedy fences, and muddy roads. There are no beautiful houses and yards with ornamental shrubs, climbing vines, and flowering plants.

THE SUBSISTENCE FARMSTEAD

The farmstead is a vital factor in farming and farm life. It is the center of the farm business. It is a place where the family is nurtured. It is a recreational center since much of the leisure time of the farm family is spent in the home. Because of its strategic position, it should be given much attention in our program of rural reconstruction. In the following pages are discussed the various features of a model farmstead designed by the U. P. Rural High School [2], showing how such a farmstead will contribute to the solution of some of our serious rural problems.

Plan of the model farmstead

The model farmstead built in August, 1939 by the U. P. Rural High School is shown in figure 1. It formed part of the exhibits shown at the 1939 Loyalty Day celebration. The farmstead measures 32 meters long and 28 meters wide, or an area of 896 square meters. This area is utilized as follows:

House and hedges	11 m. × 10 m.,	or 110 sq. m.	
Lawn and hedges	28 m. × 11 m.,	or 308 sq. m.	
Vegetable and flower garden	11 m. × 9 m.,	or 99 sq. m.	(left side)
	11 m. × 9 m.,	or 99 sq. m.	(right side)
Climbing vegetables	10 m. × 10 m.,	or 100 sq. m.	
Banana orchard	10 m. × 9 m.,	or 90 sq. m.	
Poultry project	10 m. × 9 m.,	or 90 sq. m.	

The size of the farmstead and its subdivisions may be increased or decreased, according to the available ground space.

The farmhouse

The farmhouse need not be expensive to make it attractive, healthful, as well as an efficient workshop. The house shown in figure 1 includes a sala-dining room, two bedrooms, a kitchen, and a porch.

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[2] The work of constructing the farmstead was done largely by students of the U. P. Rural High School under the direction of the following instructors: Mr. A. P. Aglibut, farm house; Mr. F. N. Salcedo, vegetable garden; Mr. S. Reantaso, poultry house and lawn; Mr. A. P. Varona and Mr. F. Barros, field crops.

Separate bedrooms provide privacy. Also, when one gets sick, he can be isolated from the rest of the family. A toilet and bathroom are on the ground floor, under the kitchen. Such a house can be built at a cost of about ₱200 if the farmer will do part of the work and can secure bamboo from his farm. The cost may be greatly reduced by decreasing the size of the house and using more of the materials that are available on the farm.

The vegetable garden

The health of the farm family may be insured by growing fruit and vegetables on the farmstead. The model farmstead has six plots measuring 1 meter by 5 meters each on the left and a similar number on the right. These plots are planted to pechay, lettuce, cabbage, eggplant, tomato, pepper, onion, and other vegetables that the family uses frequently. Two large plots are planted to pineapple.

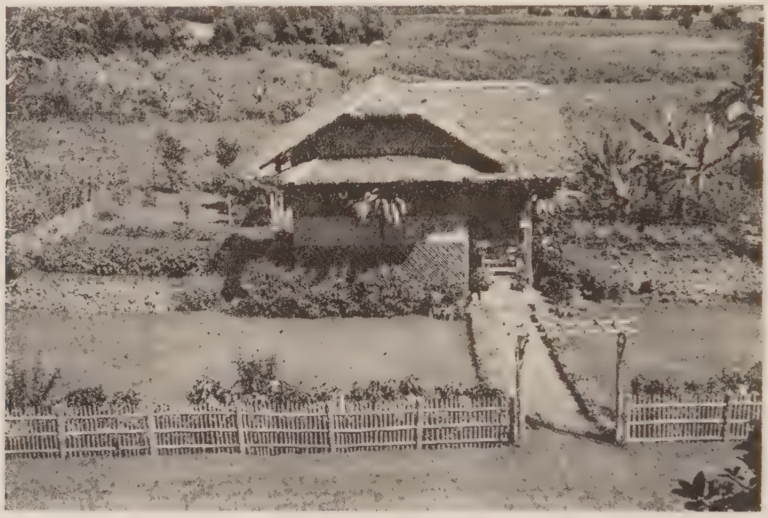

Fig. 1.—Front view of the farmstead in October, 1939, showing the house, grass lawn, hedges, vegetable garden, poultry yard, fruit trees, and three field crops adjoining the farmstead.

To supplement the cash income, certain vegetables should be grown on a bigger scale (figure 3) for the local market; there is always a big demand for these vegetables in every community. It is one way by which the farm family may keep itself profitably employed during certain parts of the year.

A lot measuring 10 meters by 10 meters is planted to vine vegetables, such as sitao, patola, patani, upo, and seguidilla. Growing a few of each of these plants will not only keep the table supplied with vegetables, but will also provide a good source of income.

Under the bananas (figure 2) is grown camote. It keeps the weeds down; at the same time, it supplies the family with shoots which can be eaten as salad or included in other food preparations.

The poultry flock

The poultry yard measures 10 meters by 9 meters (figure 2) and has a small poultry house made of inexpensive materials. Twenty-five hens are kept. A certain number of eggs are sold to recover the feed expenses. The remaining eggs are used in the home. If sold, the eggs add to the meager income of the family. The increase in the size of the poultry business during the off-season will be one way of supplementing the family income.

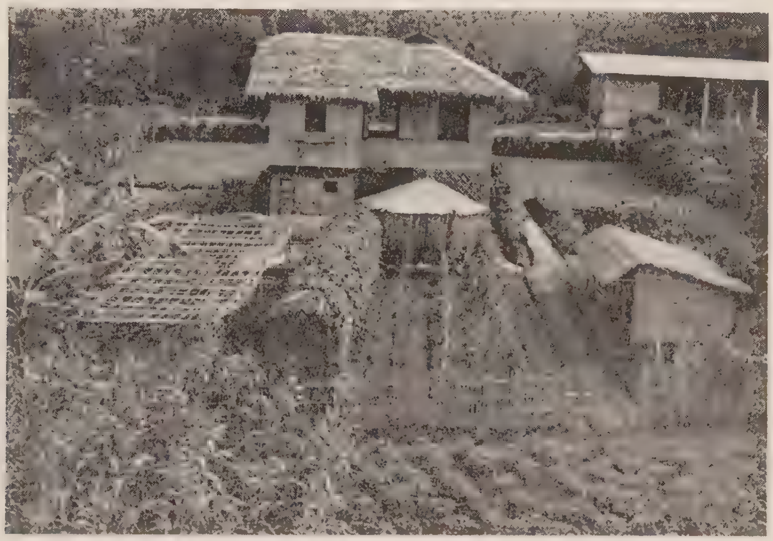

Fig. 2.—Rear view of the farmstead, showing five types of trellises for vine vegetables, greenhouse, poultry house and chickens, bananas and camote growing under, and field crops—corn, peanut, sugar cane.

In addition or in place of the poultry project, swine may be raised. For sanitary reasons they should not be confined near the farm house.

The fruit orchard

On the poultry yard are eight different fruit trees: namely, chico, pummelo, mandarin, calamondin, lanzones, avocado, star apple, and jack fruit (figure 1). They will not only serve as shade for the chickens, but also provide fruit for the family.

A lot measuring 10 meters long and 9 meters wide is planted to twelve hills of bananas. These bananas, if properly cared for, will provide fruit for the family. When money is needed, the fruit can be readily sold.

On the two sides of the lawn are planted papaya trees. Since the number of fruit which a selected tree (figure 3) may produce is great, it is possible for ten selected papaya trees to increase considerably the income of the farm family. The fruit consumed at home will improve the family diet.

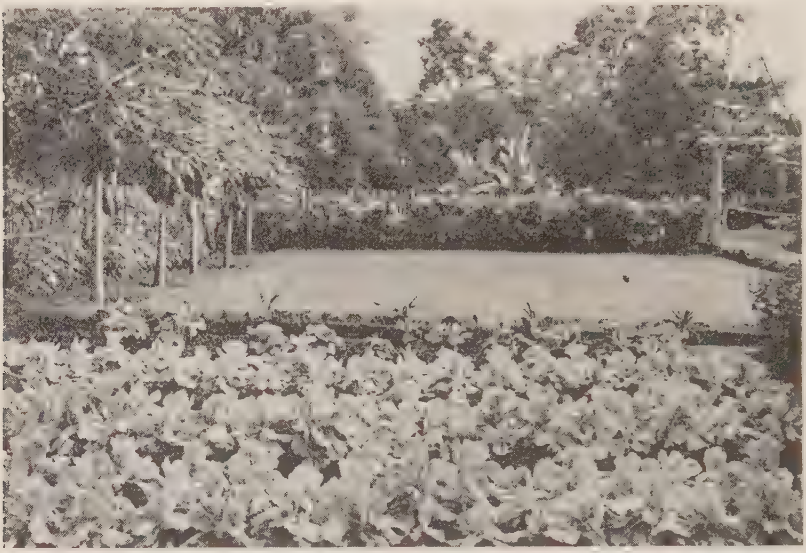

Fig. 3.—View of the area on the left side of the house, showing plots planted to vegetables for the market. The papaya trees heavily laden with fruit, the hedges along the bamboo fence, and the grass lawn can be seen.

Beautification

The model farmstead is enclosed with a bamboo fence. Along the fence are hedges. Hedges also surround the farm house. There are two plots of flowering plants on the left and two on the right side of the house.

The grass lawn occupies about one-third of the farmstead area. It separates the house from the road by 11 meters. The house is in this way kept free of dust.

The lawn serves as a playground for the children, who will find it a better place than the dusty road.

A small shed behind the house serves as a greenhouse for air plants and potted plants requiring partial shade (figure 2).

THE FARMSTEAD IN THE SOLUTION OF RURAL PROBLEMS

The contribution which the farmstead can give to the solution of various farm problems is now evident and may be briefly summarized.

In matters of health, the homestead provides the family with sufficient food—vegetables, fruits, meat, and eggs, which are necessary for an adequate and balanced diet. It provides a grass lawn for children to play upon. It eliminates the muddy and dirty yard, which is a breeding place for disease. In its place is a sanitary and healthful surrounding.

From the economic point of view, the farmstead helps lower living expenses. It enables the farm family to be profitably employed during the off-season or when there is little productive work on the farm. Since the income of the common farmer is meager, the additional income from vegetables, fruits, poultry, and eggs from the farmstead will materially increase the earnings and raise the standard of living of the farm family.

In educational matters, improved financial standing will enable the family to keep children in school long enough to make them better citizens.

In civic matters, the farmer will become a peaceful and contented citizen as a result of increased satisfaction in life. It will be difficult for trouble makers to induce him to join movements in which he is often the loser.

In recreation, the farmstead provides a place better than the street for the children's games. Both young and old will find in the garden, orchard, and poultry project something to attract their attention and increase their enjoyment of farm life.

Although communication problems are largely for the government to solve, the interest generated in the improvement of his farmstead will eventually lead the farmer to improve the road bordering his yard.

In aesthetic matters, the architecture of the house, the well-kept lawn, the hedges, the flowers, the fruit-laden trees, and the sanitary appearance enhance the beauty of the farm and the country. As a result, rural boys and girls will be attracted to stay on the farm. They will realize the value of farming as a means of earning a living and as a mode of life.

In order to promote rural reconstruction in this country, our educational agencies of the government, principally the Bureau of Plant Industry, Bureau of Education, Office of Adult Education, and the College of Agriculture, should be given adequate support so that their rural improvement program may be given the needed emphasis.

INTRODUCTION OF TSAMPEDAK AND SUSPECTED CASE OF NATURAL HYBRIDIZATION IN ARTOCARPUS[1]

By N. B. Mendiola
Of the Department of Agronomy

According to Merrill (1912 and 1923) the genus *Artocarpus* is composed of some 50 or more species, 18 of which are found in the Philippines. Of these 18, three produce fruit for the table: namely, the jackfruit, *A. integra* (Thunb.) Merr.; marang, *A. odoratissima* Blanco; and *tsampedak*, *A. champeden* (Lour.) Spreng., or *A. polyphema* Pers.[2] One species gives fruit which is eaten after boiling or baking. This is *A. communis* Forst., the species to which the seedless form, the breadfruit, and the seedy form, *kamansi,* belong.

It is possible that other species are grown or are used as sources of edible fruit in other countries. For example, the fruit of *A. rigida* Bl., the *mandalika,* or *peusar* of Java, is eaten raw in that country. We also have this species in the College Economic Botanical Garden, but we have not been able to gather a ripe fruit from it for local trial.

While the author uses the name *tsampedak* for *A. champeden,* horticulturists of the Bureau of Plant Industry have been using the word *lemasa* in its place. According to a letter from Mr. Hilarion S. Silayan, Director of that Bureau, *lemasa* is the common name recorded in their introduction books for *A. champeden.* This common name, as far as I have been able to find out, was first published in 1918 (Wester, 1918) in Philippine agricultural literature. It should be pointed out, however, that, according to two well known Java authors (Heyne, 1927, and Ochse, 1931), neither *lamasa* or *lemaso,* which are folknames in Dutch East Indies applied to *A. integra,* is used for *A. champeden* and *lemasa* is *A. integra.* For this reason, it is proposed in this paper that, in Philippine literature, the word *lemasa* as meaning *A. champeden* be dropped and the Malay name *tsampedak* be used instead for accuracy and simplicity.

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[1] A revision of a paper read before the Los Baños Biological Club, September 28, 1939. Experiment Station contribution No. 1347.

[2] According to Corner (1939) the legitimate botanical name of the jackfruit should be *Artocarpus heterophyllus* Lam., while that of the tsampedak is *Artocarpus integer* (Thunb.) Merrill.

Tsampedak is a good fruit and should be widely grown in the Philippines. In spite of the fact that the jackfruit is found all over the Philippines, it has been an aim in our Department of Agronomy to introduce *tsampedak* throughout the country because of many qualities in which it excels its relative. Outstanding among these are: the practical absence in the fruit of the unwanted latex, resistance of the fruit to the attack of pests which damage the nangka fruit very badly, easiness of separation of the core and of the edible sections, and greater degree of sweetness and apparent digestibility of the flesh. Its fruit is smaller than the jackfruit and is more aromatic or odorous, but these are not necessarily undesirable characters.

Introduction of Artocarpus champeden into the Philippines. It appears from records that *tsampedak* was first introduced into the Philippines under government auspices by the former Bureau of Agriculture in 1912 when it acquired some plants from China, but that introduction failed. Some plants were again introduced in 1913, this time from the Singapore Botanic Gardens, but this introduction also failed. More plants were introduced in 1915 from the same source and this time the introduction was successful. It is said that all tsampedak plants now found in the various stations of the Bureau of Plant Industry and those distributed throughout the different provinces, particularly Iloilo and Occidental Negros, came from this introduction. The first plant of this introduction fruited in 1920.

The College of Agriculture first introduced *tsampedak* into its cultures in 1913, direct from Buitenzorg, Java. Its second introduction was in 1915 from the Bureau of Agriculture, evidently a part of the second introduction made by that Institution in the same year. Nothing appears in our records regarding the results of these two importations.

The third and last introduction was made by the College on January 25 and March 2, 1927, when the Department of Agronomy received from the author seeds collected by him from Sandakan, Borneo and shipped from Buitenzorg, Java. It would appear then that, between 1912 and 1927, at least five introductions of *tsampedak* were made from foreign places as China, Singapore, Java, and Borneo, but that only two of these introductions were successful. Nearly twenty years have passed since the *tsampedak* fruited in the Philippines and yet this fruit has not become so popular as other comparatively new fruits. The people in many provinces seem to know and hear little about it.

Review of literature

No explanation has so far been offered for this slow progress of the spread of the *tsampedak,* and it is quite surprising to note the practical absence of Philippine literature on this fruit. All the information which the author has found about it consists of notes on the introductions and their results already described; namely, a statement by Wester (1918 and 1920) to the effect that *lemasa* (*A. polyphema* Pers.) was one of the fruit species introduced early by the former Bureau of Agriculture but was not then found outside government stations; a statement by Galang (1920) describing the tree and fruit produced at Lamao Station; Merrill's (1923) listing, in his enumeration of Philippine flowering plants, *A. polyphema* Pers. as one of excluded *Artocarpus* species and calling attention to the fact that the proper name for it is *A. champeden* (Lour.) Spreng., and that it had been recently introduced into the Philippines and was being cultivated at Lamao; Wester's (1924) description of *A. champeden* (Lour.) Spreng. pointing out its recent introduction and fruiting in Lamao; the author's (Mendiola, 1928) listing *A. champeden* as one of a number of plants introduced by him in connection with a trip he made in Malaya and Java; and lastly, Padolina's (1931) report on budding *tsampedak* on nangka.

On June 24, 1936, the author wrote the Director of the Bureau of Plant Industry to inquire about the popularization of the *tsampedak* in the Philippines and to suggest exchange of the fruit of this plant for comparative study. On April 17, 1937, he received a fruit which was supposed to have been harvested from one of the tsampedak trees growing at the Lamao Station. However, when this fruit was opened and examined it turned out to the author's surprise, to be no different from that of a jackfruit. He reported this observation to the Director and suggested that a possible reason for the Bureau's not advertising their *tsampedak* was that its fruit was not any different from a jackfruit.

It was then that the author began to suspect that there is natural crossing between jackfruit and *tsampedak* and that the fruit he received from the Bureau might have come from a tree which arose from a seed that was produced on a tsampedak tree here in the Philippines. He voiced this suspicion to the Director of the Bureau of Plant Industry in the report referred to. Unfortunately nothing could be found in available literature regarding natural hybridization among *Artocarpus* species and it was then impossible to check this suspicion. However, Corner's (1939) statement that both the jackfruit and *tsampedak* seem to be insect-pollinated is suggestive.

Object of the present paper

The object of this paper is to report certain observations on the behavior of certain tsampedak trees which would tend to confirm the supposition mentioned regarding natural cross-pollination between *A. champeden* and *A. integra* and which would serve as a partial explanation for the slow progress obtained in the popularization of the culture of the *tsampedak.*

Time and place of observations

The observations herein reported were made on the author's experimental culture and cover a period of about twelve and one-half years—from 1927 to date.

MATERIALS AND METHODS

The observations reported in this paper were made on four groups of plants, namely:

1. Plants raised from seeds of a fruit which was gathered in Sandakan, Borneo, in 1926.
2. First generation offspring of plants in group 1, including suspected (*A. champeden* × *A. integra* hybrid), all from seeds produced locally on tsampedak trees grown beside nangka plants.
3. Seedlings from seeds of suspected hybrid mentioned in group.
4. Seedlings of *A. integra.*

OBSERVATIONS AND RESULTS

Of the first group of the plants raised from the seeds originally collected in Sandakan, Borneo, the author has records of the fruiting of two trees which are designated here as Tree 1 and Tree 2. Tree 1 first fruited in the yard of the author on Faculty Hill in the summer of 1932. Only one fruit was then produced. In the summer of 1933, the same plant produced two fruits, in 1934 eleven fruits, and in 1935 thirty-five fruits. A heavy storm which occurred in December, 1936, blew the tree down.

Tree No. 2 is at Aliaga, Nueva Ecija, where Mr. Vicente B. Aragon took the plant. He reported that it first fruited in 1936 with three fruits. Since then it has been yielding more than a dozen fruits a year.

The fruits which have been produced by trees Nos. 1 and 2 were normal tsampedak fruits.

On plants of the second group. From the tsampedak seeds of fruits harvested locally in 1932 and 1934, a number of plants were raised. One plant raised from the 1932 seed fruited in 1937 while another from the 1934 seed fruited in the summer of 1939. The fruits from both of these plants possessed mostly nangka characters: they were larger than tsampedak fruits and possessed abundant latex, high susceptibility to pests, firm flesh, and difficulty of separation of the core and the sections. The trees, however, fruited when they were smaller than nangka trees at their first fruiting year.

On plants of groups 3 and 4. Group 3 is formed by seedlings raised from seeds of the suspected natural tsampedak-nangka hybrid. These seedlings were observed for variation that might indicate the hybrid nature of their parent. They were compared with seedlings of nangka (plants of group 4) and of *tsampedak* (group 1 in their seedling state). For additional evidence of the hybrid nature of the suspected tsampedak-nangka hybrids already discussed, it would be necessary to study the mature offspring of these hybrids. However, these offsprings, are still in the seedling state and the author has to be content with using the characters of seedlings for study of hybridity.

Table 1 describes certain characters of the offspring of the three parents mentioned—*tsampedak*, suspected tsampedak-nangka hybrid, and nangka.

TABLE 1

Variability in leaf characters of Artocarpus seedlings

CHARACTERS STUDIED	A. CHAMPEDEN	(A. CHAMPEDEN X A. INTEGRA) F_2	A. INTEGRA
	f	*f*	*f*
Leaf margin:			
Entire	25	72	106
Deeply lobed	1	6	1
Some leaves entire, the rest lobed	0	25	21
Leaf shape:			
Elliptical	20	3	3
Oblong	3	33	17
Elongated	2	70	108
Leaf surface:			
Lower surface rough	4	95	128
Both surfaces rough	22	11	0
Position of leaves:			
Pointing upward at 30° angle with stem	0	106	123
Horizontal	6	0	5
Pointing downward	15	0	0

The data in the preceding table show that in several characters, taken together, the offspring of the suspected natural hybrid between *tsampedak* and nangka differs from those of either parent.

DISCUSSION OF RESULTS

Existence of natural crossing between A. champeden and A. integra. The results which have been presented as well as the fact that a supposedly tsampedak tree at the Lamao station produced fruits bearing nangka characters may better be interpreted as a result of natural crossing between *A. champeden* and *A. integra* than as any other phenomenon, such as mutation. The fact should be mentioned here that one of some sister plants of the suspected tsampedak-nangka hybrids, which were given to Mr. Galicano Ylagan of the College Infirmary, fruited last summer also and turned out to be a tsampedak, proving that, as may be expected, while some female flowers of a tsampedak tree may be cross-pollinated with nangka flowers, some may escape this clandestine pollination and become crossed with male flowers of the same plant.

The foregoing results also tend to explain the probable origin of some peculiar forms of nangka which have been observed in College cultures in the past. Before the year 1932, there had been observed on the Campus several supposedly nangka trees which in shape and size of fruit were very different from the ordinary nangka. For example, there used to be one such plant between the two old poultry buildings. The fruit was rather small and oblong in shape, but the internal characteristics were those of nangka. However, no fruit with real tsampedak characteristics had then been reported. It is quite probable that these trees were from introduced tsampedak seeds which had been naturally crossed with nangka in the place of origin. As mentioned earlier in this paper, *tsampedak* was introduced into the College cultures in 1913 and 1915.

Natural hybridization between tsampedak and nangka a disadvantage in the popularization of the tsampedak culture. The fact that a seed of a *tsampedak* plant may be planted and the resulting offspring produce not a tsampedak plant but one akin to a nangka would not only prevent a normal multiplication of the *tsampedak* but would also tend to discourage growers from growing this fruit species. If nangka characters which are horticulturally important were recessive instead of dominant to their allelomorphs, natural hybridization would not have the same undesirable effects. But since these characters are dominant, propagation of *tsampedak* by seed results in a certain number of the offspring's not coming true to the tsampedak type. It would seem that if our horticulturists desire to see the culture of this fruit popularized here, they will have to discover a convenient method of asexual propagation. Preliminary trials of marcotting and inarching on nangka stocks made by Dr. Leon G. Gonzalez of our Division of Pomology and his students on the author's tree on Faculty Hill tend to show that it would not be easy to marcot this species and that inarching may be an easier method to use even if the stocks used be the nangka. In Java, where marcotting is the asexual method of propagation used by the common fruit growers, the marcotting of *tsampedak* has not been reported. In 1927, Ochse reported that this plant was asexually propagated, but with great difficulty, by budding with yearling tsampedak seedlings used as stocks and dormant buds as scions, but in his book published in 1931, the mention of even this method of propagation is omitted. Should we fail to discover the proper methods of asexual propagation of *tsampedak* and be forced to stick to multiplication by seed, it would be necessary to grow parent tsampedak plants in places isolated from the nangka.

SUMMARY AND CONCLUSION

The production of plants bearing important *Artocarpus integra* characters from seeds of an *Artocarpus champeden* parent is reported in this paper. This phenomenon is interpreted as an evidence of the existence, at least in this locality, of natural hybridization between these two species of *Artocarpus* and is considered a hindrance to the rapid propagation of *tsampedak* and the popularization of its culture.

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TOMATO PLANTS GROWN IN CHEMICAL SOLUTIONS ADDED TO LAKESHORE SAND[1]

FELIX B. ROBLES

WITH THREE TEXT FIGURES

Recent studies that have attracted the attention of those interested in plant production include the growing of plants in chemical solutions,—culture solutions. Fairly good growths have been obtained with a number of plants of economic value. In California for example, Dr. William Gericke was able to grow vegetables, including tomatoes, in tank cultures provided with an electrical heating device. But where the air temperature is favorable, the use of the heating device is unnecessary. As a general rule, however, the formulae of the culture solutions employed are not revealed; besides, the solution cultures do not provide the roots of some plants with an ample supply of oxygen for respiration.

For these reasons, in the present experiment, several combinations of known chemical salts were added in aqueous solutions to the ordinary lakeshore sand in pots, and in these culture media tomato plants were grown to maturity. Inasmuch as the sand used no doubt contained a small amount of plant nutrients of one kind or another, it is presumed that the molecular salt proportions employed must have been modified when the solution was poured into the sand. The stand, however, of the tomato plants in the sand was so poor when supplied only with distilled water that the molecular salt proportions tried may be considered only slightly altered. In the present study, three main objectives were kept in mind: to find culture solutions that are suitable to tomato plants; to produce tomatoes for home use; and to employ materials, such as sand, pots, and chemicals, that are easy to secure.

Review of literature

Available scientific literature on the mineral nutrition of the tomato plant appears rather limited. Popular articles on this plant, such as those that have appeared from time to time in certain local daily papers and in other non-technical papers, are so general in scope or nature that it is unwise to include them in this review.

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[1] Experiment Station contribution No. 1348. Prepared in the Department of Agricultural Botany under the direction of Professor Rafael B. Espino.

Clark and Shive (1934) grew tomatoes in a culture solution which contained approximately equal molar concentrations of NH_4-N and NO_3-N; it had, in preliminary studies, produced good growth of this plant. This solution contained 0.0021 molar KH_2PO_4, 0.00292 molar $Ca(NO_3)_2$, 0.0071 molar $MgSO_4$, and 0.0028 molar $(NH_4)_2SO_4$. They found that the plants grown in this solution over a wide range of pH values did not show significant differences in the external appearance of the tops. Differences were noted, however, with the rate of absorption of NH_4-N and NO_3-N by the plants. More NH_4-N was absorbed at a high pH, while more NO_3-N was absorbed at a low pH value. However, the maximum rate of NH_4-N absorption was higher than the maximum rate of NO_3-N absorption in the younger plants.

Tiedjens (1934) reported that tomato plants grown in complete culture solution containing ammonium sulfate became definitely more succulent than those in which the nitrogen was supplied only as nitrate. He further noted that the ammonium-supplied plants were more spreading than the nitrate-fed plants, but the latter had longer internodes than the former. He studied the assimilation of these two forms of nitrogen by the tomato plant and found that the ammonium ion was more readily absorbed and assimilated than was the nitrate ion.

Tiedjens and Robbins (1931) were able to grow tomato plants to maturity which produced a heavy yield of commercial fruits when supplied with a complete 4-salt culture solution in which nitrogen was present only as ammonium. They also noted that the reaction of the culture medium affected the assimilation of both forms of nitrogen by tomato plants.

Objects of this study

The objects were (*a*) to discover a method simple enough for raising good tomatoes on the railings of porches and windows, (*b*) to determine the approximate salt requirements of the plant, and (*c*) to determine, incidentally, its nitrogen requirements.

Time and place of this study

This study was conducted in the experimental yard of the Department of Agricultural Botany from November 10, 1937, to February 8, 1939.

MATERIALS AND METHODS

Plants

Tomato plants of a native variety common in local markets were used. Seeds were sown in moist sand in a seed-box; and when the seedlings were about eight centimeters in height and had two or three leaves, they were transplanted to the pots, one seedling to each.

Sand

The sand was obtained from the shore of Laguna de Bay at Calamba. It was sifted and washed with tap water. Washing was done repeatedly until the water used was no longer turbid. Eight kilograms of air-dry sand were placed in each of the tin cans.

Culture solutions

Single-salt stock solutions. Except secondary calcium phosphate, which was difficult to dissolve in water, the different single-salt stock solutions were prepared in one molar concentrations as described by Espino (1920). The secondary calcium phosphate was prepared in M/10 concentration. From these single-salt solutions the required amounts of salts were pippeted and mixed together in a volumetric flask. The salts were "Baker" analyzed monopotassium phosphate (KH_2PO_4), calcium nitrate ($Ca(NO_3)_2$), magnesium sulfate ($MgSO_4$), ammonium sulfate ($(NH_4)_2SO_4$), and secondary calcium phosphate ($CaHPO_4.2H_2O$). The ferric phosphate, which was used to supply iron, was prepared in the manner described by Livingston (1919). Distilled water was used as a solvent.

The 3-salt type I. Each culture solution contained three salts—KH_2PO_4, $Ca(NO_3)_2$, and $MgSO_4$—to which a few drops of ferric phosphate suspension were added. The molecular salt proportions and the total concentrations employed are not given here. The 3-salt culture solutions were separately watered or poured into the pots containing sand at the rate of 250 ml. a week, and unless otherwise specified, the weekly watering was continued until the cultures were harvested.

The 4-salt type A. Each culture solution contained all the salts of the 3-salt type I and a certain amount of ammonium sulfate ($(NH_4)_2SO_4$). The molecular salt proportions and the total concentrations of the different culture solutions tried are not given here. At the rate of 250 ml. a culture a week, these culture solutions were applied to the plants until maturity.

The 4-salt type B. Each culture solution contained all the salts in the 4-salt type A, except that the nitrogen was supplied only as ammonium from ammonium sulfate. The $Ca(NO_3)_2$ in the 4-salt type A was substituted by $CaHPO_4.2H_2O$. The molecular salt proportions and concentrations of the different solutions tried are not given here. These culture solutions were also applied separately to the different cultures at the rate of 250 ml. a week and watering was continued until the plants were harvested.

Culture solutions with secondary essential elements. Three promising culture solutions were selected from those previously tried. They were the 3-salt solution 9-15-3, the 4-salt type A solution 2-6-6-2, and the 4-salt solution type B 3-9-6-6. The 3-salt solution was made up of 9 parts KH_2PO_4, 15 parts $Ca(NO_3)_2$, and 3 parts $MgSO_4$. Eight quadruplicate cultures of this kind were prepared to which were added 10 p.p.m. of $ZnSO_4$, $Na_2B_4O_7$, and $MnSO_4$, singly or in certain combinations. The 4-salt type A solution contained 2 parts KH_2PO_4, 6 parts each of $(NH_4)_2SO_4$ and $Ca(NO_3)_2$, and 2 parts $MgSO_4$. Also eight quadruplicate cultures of this type were prepared to which were added 10 p. p. m. of the stimulant salts, singly or in certain combinations. The 4-salt type B solution contained 3 parts KH_2PO_4, 9 parts $(NH_4)_2SO_4$, and 6 parts each of $CaHPO_4.2H_2O$ and $MgSO_4$. Again, eight quadruplicate cultures of this kind were prepared and supplied with 10 p. p. m. of the stimulant salts, singly or in certain combinations. In these experiments the stimulants were prepared in concentrations equal to the total molecular concentrations of the culture solution, so that the 10 p. p. m. consisted of one million parts of the culture solution and 10 parts of the solution of any of the stimulants.

Amount of culture solution needed to bring tomato plants to maturity. The 4-salt type A 2-6-6-2 solution was again prepared, this time, for thirteen quadruplicate cultures. Stimulants or secondary essential elements were also added in amounts and combinations as shown in table 1. The culture solutions were supplied weekly at the rate of 250 ml. to each pot. The cultures received varying amounts of the solutions or in varying durations. Culture I received only 250 ml. of the culture solution during the growth period of the plants; II, 500 ml.; III, 750 ml.; IV, 1000 ml.; V, 1250 ml.; VI, 1500 ml.; VII, 1750 ml.; and VIII to XIII, 2000 ml. each—all at the rate of 250 ml. a week until the total amounts required were supplied. Upon reaching the eighth 250 ml. weekly application of the culture solution, the plants appeared already matured and were loaded with fairly well-developed fruit. Watering with the culture solution was thereafter discontinued; only distilled water was added to the cultures weekly or whenever needed until the plants were all harvested.

Care of cultures

The cultures were equally exposed to sunlight and rain. They were frequently weeded and cultivated and, at weekly intervals, supplied either with the required amounts of culture solutions or with distilled water. To prevent rapid evaporation of water, each pot was covered with thick Manila paper coated with paraffin cut to fit the pot. Harmful insects found on the leaves and stems of the plants were killed as soon as discovered.

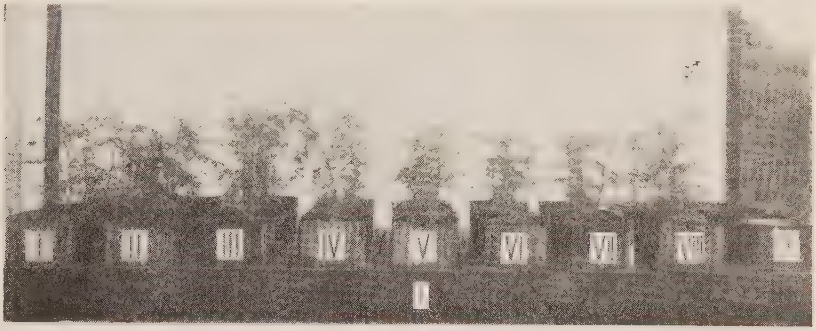

Fig. 1.—Tomato plants grown in sand supplied with a promising 3-salt type I culture solutions with an initial total concentration of 0.0837 gram-molecule (of all the salts taken together) per liter, plus some stimulants applied singly or in combination, each at 10 p.p.m. Culture I received culture solution only; II, zinc; III, boron; IV, manganese; V, zinc and boron; VI, zinc and manganese; VII, boron and manganese; VIII, zinc, boron, and manganese; and IX, distilled water only. The salt proportion was 9–15–3. Cultures from October 20, 1938, to January 5, 1939.

EXPERIMENT AND RESULTS

Four series of culture experiments were performed at different times. They may be described briefly as follows:

First series. This was performed from November 10, 1937, to February 28, 1938, and consisted of sand cultures of tomatoes supplied with the 3-salt culture solutions in three different total molecular concentrations. In these cultures, the plants were supplied with nitrogen only as nitrate from $Ca(NO_3)_2$. On reaching maturity the cultures were harvested.[2] Selected cultures are in table 1.

Second series. This was conducted from June 4, 1938, to September 5, 1938, and consisted of a number of culture solutions of the 4-salt type A and 4-salt type B. Each type included culture solutions of different salt proportions and three total molecular concentrations. At maturity the cultures were harvested.[3] In type A, the culture solutions contained nitrogen both as nitrate from $Ca(NO_3)_2$ and as ammonium from $(NH_4)_2SO_4$, while in type B the culture solutions contained nitrogen only as ammonium from $(NH_4)_2SO_4$. Selected cultures are in tables 2, 3, and 4.

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[2] The experimental data are on file in the Department of Agricultural Botany.

Third series. This was carried out from October 20, 1938, to January 5, 1939, and consisted of a 3-salt culture solution, a 4-salt type A solution, and a 4-salt type B solution. These solutions were selected from among those tried in the first and the second series of experiments as being quite promising for the tomato plants. To them were added 10 p. p. m. of certain stimulants, either singly or in combinations of two or three. On reaching full development of the plants, the cultures were photographed (fig. 1-3) and later harvested.[4] Selected cultures are in table 5.

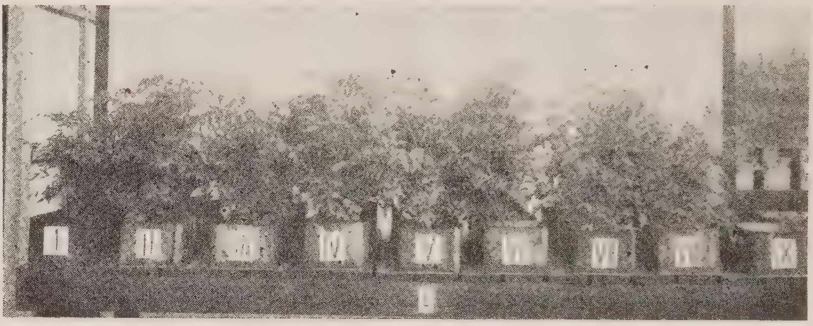

Fig. 2.—Tomato plants grown in sand supplied with a promising 4-salt type A culture solution with an initial total concentration of 0.0768 gram-molecule (of all the salts taken together) per liter plus some stimulants applied singly or in combination, each at 10 p.p.m. Culture I received culture solution only; II, zinc; III, boron; IV, manganese; V, zinc and boron; VI, zinc and manganese; VII, boron and manganese; VIII, zinc, boron, and manganese; and IX, distilled water only. The salt proportion was 2–6–6–2. Cultures from October 20, 1938, to January 5, 1939.

Fourth series. This was conducted from November 17, 1938, to February 8, 1939. A promising culture of the 4-salt type A in the third series was employed. The cultures were harvested when the plants had almost matured fruits. The relative values of average harvest data are recorded in table 6 with the highest actual value under each criterion of result arbitrarily taken as 100.

[3,4] The experimental data are on file in the Department of Agricultural Botany.

Criteria of results. The experimental data obtained were: (*a*) height of plants, (*b*) dry weight of roots, (*c*) fresh weight of tops, (*d*) dry weight of tops, (*e*) fresh weight of tops and fruits, (*f*) number of flowers, (*g*) number of fruits, and (*h*) yield of fruits. These data were not all used at the same time; the exact number may be seen in the different tables. The selection of the criteria of results depended upon the convenience of the writer. The heights of the plant were measured from the base of the culms to the tips of the tallest leaves. The other criteria of results employed are too obvious to require further explanation.

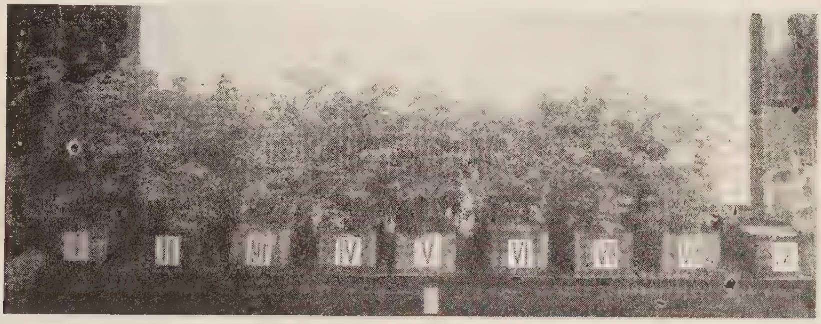

Fig. 3—Tomato plants grown in sand supplied with a promising 4-salt type B culture solution with an initial total concentration of 0.1152 gram-molecule (of all the salts taken together) per liter plus some stimulants applied singly or in combination, each at 10 p.p.m. Culture I received culture solution only; II, zinc; III, boron; IV, manganese; V, zinc and boron; VI, zinc and manganese; VII, boron and manganese; VIII, zinc, boron, and manganese; and IX, distilled water only. The salt proportion was 3–9–6–6. Cultures from October 20, 1938, to January 5, 1939.

DISCUSSION OF RESULTS

Limitations to consider

This study was made primarily to discover at least a culture solution which, when added to the lakeshore sand in pots, would make tomato plants grow well and produce fruit abundantly. Being more for practical than for scientific purposes, this experiment utilized easily obtainable materials, and no attempt was made to analyze the lakeshore sand for its plant-nutrient contents. It should be said, however, that all the tomato plants grown in the sand, which was supplied only with distilled water, remained very small; in some cases, they even finally died—indicating that any improvement in growth beyond this stage was undoubtedly due to the culture solutions employed.

Nutritive value of the 3-salt solutions

In order that the most promising 3-salt culture solutions might be selected, actual values obtained under each criterion of results with each concentration were reduced to relative values. It was revealed that culture VII of the total concentration 0.0837 gram-molecule (of all the salts) per liter may be considered as the most promising in this lot (table 1). The second most promising culture solution was culture II of the same total molecular concentration. In yield of fruit, cultures II and IX of the total concentration 0.0558 gram-molecule were the best. But later culture experiments revealed that the 3-salt culture solutions were decidedly surpassed by other types of culture solutions, indicating that the nitrate nitrogen alone is probably not the best for the plant.

Nutritive values of the 4-salt type A solutions

That it might be easy to choose the most promising culture solutions of the 4-salt type A for tomato, actual values under each criterion were converted into relative values. It was revealed that the most promising 4-salt type A solutions were cultures VII, VI, and III, with the total concentration of 0.1152 gram-molecule (of all the salts) per liter, and culture VI, with the total concentration of 0.0768 gram-molecule (of all the salts) per liter (table 2).

Nutritive values of the 4-salt type B solutions

In order that the selection of the most promising culture solutions might be facilitated, the actual values were converted into relative values (table 3). The results show that the largest number of H's fall on culture V, which had a total concentration of 0.1152 gram-molecule (of all the salts) per liter. Equally good were cultures VI and VII, although each received only one H out of four criteria of results that were used.

Comparison of the most promising 4-salt solutions in types A and B

Since the culture trials that employed 4-salt solutions of types A and B were conducted at the same time, their results are comparable. By establishing relative values from the actual values obtained, it was revealed in table 4, that culture V of the 4-salt type B may be considered as the most suitable for the vegetative growth and development of the tomato plants in the lot. But in yield of fruits, culture VII in the two higher total molecular concentrations of the

4-salt types A and B was the best in the lot. It should, however, be pointed out that this set of cultures was harvested before the plants were all able to produce fruits. It appears, therefore, that culture V might have also produced more if given the time.

Promising cultures with secondary essential elements

Having been gathered at the same time, the data obtained are comparable. But to simplify comparison, only the three highest actual values under each criterion were transferred to table 6 as relative values. It was revealed that most of the promising cultures are located in the lower part of the table. Fairly good cultures may also be found in the middle portion of the table. But not a single good culture appears in the upper portion of the table.

For these reasons, it appears that for good growth and development and high yield of fruit, the tomato plants require, in addition to other essential elements, ammonium nitrogen alone or a combination of both ammonium nitrogen and nitrate nitrogen. Nitrate nitrogen alone in complete culture solution seemed not quite suitable or was inadequate for the plant (fig. 1-3). The superiority of ammonium nitrogen for tomato plants over the combination of nitrate nitrogen and ammonium nitrogen shown in table 4 is confirmed by the results in table 5.

In regard to the influence upon tomato plants of secondary essential elements when added to more or less balanced culture solutions, it appears that most of the promising cultures were supplied with the stimulants or secondary essential elements. It may, therefore, be possible to conclude that under the conditions of this experiment, 10 p.p.m. of $ZnSO_4$, $Na_2B_4O_7$, and $MnSO_4$, added either singly or in certain combinations to the selected 4-salt solutions of types A and B, produced better developed and more productive tomato plants than the control cultures that received no stimulants at all.

It appears in table 5 that cultures IV and V of the total molecular concentration of 0.1152 gram-molecule (of all the salts) per liter were the best or the most promising in the lot. Both of these culture solutions contained 3 parts of KH_2PO_4, 9 parts of $(NH_4)_2SO_4$, and 6 parts each of $CaHPO_4 \cdot 2H_2O$ and $MgSO_4$. But culture IV had in addition 10 p.p.m. of $MnSO_4$, whereas culture V received an additional supply of 10 p.p.m. of $ZnSO_4$ and 10 p.p.m. of $Na_2B_4O_7$.

Amount of culture solution needed to bring tomato plants to maturity

In table 6 all the values of 90 and above are indicated by H's, and show that the best results were obtained after the cultures had received the seven or the eight weekly applications of 250 ml. of the culture solution.

At the time of harvest, the fruit from each of the quadruplicate cultures were weighed. The results showed that cultures VII and VIII produced 2076 and 2025 grams of tomato fruits respectively, the two highest yields in the lot. Therefore, 1.75 to 2 liters of the culture solution containing 2 parts of KH_2PO_4, 6 parts each of $(NH_4)_2SO_4$ and $Ca(NO_3)_2$, and 2 parts of $MgSO_4$ with a total concentration of 0.0768 gram-molecule (of all the salts) per liter and supplied with 10 p.p.m. each of $ZnSO_4$ and $MnSO_4$ (table 6) were enough to bring the tomato plants to full maturity. Owing to the excellent growth and high yield of tomatoes, this solution should be considered also as very promising for tomato in sand culture.

With the higher amount of two liters taken for computation, it was found that the amount of the culture solution required to bring the plant to maturity contained 250 ml. of M/1 KH_2PO_4, 750 ml. M/1 each of $(NH_4)_2SO_4$ and $Ca(NO_3)_2$, and 250 ml. of M/1 $MgSO_4$, together with the little amounts of the stimulants $ZnSO_4$ and $MnSO_4$ and a few drops of ferric phosphate suspension. In the form of crystals, the total amount of each of the main salts needed to bring the tomato plant to full development and produce ripe fruits was found to be as follows: 34.03 grams of KH_2PO_4, 99.11 grams of $(NH_4)_2SO_4$, 177.12 grams of $Ca(NO_3)_2$, and 61.63 grams of $MgSO_4$.

Results of present study in the light of available literature

In this study an attempt was made to compare the nutritive values for tomato plants of the 3-salt type I, the 4-salt type A, and the 4-salt type B. In the first, nitrogen was supplied as nitrate only; in the second, as ammonium and as nitrate; and in the third, as ammonium alone. The results have shown that the NO_3-fed tomato plants were very much inferior to those that were supplied either with both NH_4- and NO_3-nitrogen or with NH_4-nitrogen only. These observations could be better appreciated if compared with the available literature on the subject.

The rather poor stand of the tomato plants, when supplied in the 3-salt solution with nitrogen only as nitrate, was previously observed by Espino (1920) with young rice plants. This apparent inadequacy or unsuitability of this form of nitrogen for tomato plants was found by Tiedjens (1934) and Clark and Shive (1934) to be due to the fact that the NH_4-nitrogen was more readily absorbed and assimilated by the tomato especially the younger plants, than was the NO_3-nitrogen. With cotton seedlings, Naftel (1931) found that the NH_4-ion. was also more readily absorbed than was the NO_3-ion.

Comparison of the appearances of the NO_3-fed plants and the NH_4-fed (figs. 1, 2, and 3) seems to substantiate Tiedjens' (1934) observation. Tiedjens observed that the tomato plants supplied with ammonium sulfate were more succulent and spreading than the NO_3-fed plants.

It was rather difficult to pick the culture solution best for tomato plants from the 4-salt type A and B cultures tried. A number of the cultures produced more or less equally vigorous and fruitful plants, an observation which seems to confirm the report of Clark and Shive (1934). But the results from the present study seem to show that the tomato requires for its normal development a relatively large amount of nitrogen derived either from NH_4 alone or from a combination of NH_4 and NO_3, with relatively low amounts of KH_2PO_4 and $MgSO_4$ (tables 2, 3, and 4). The fact that the tomato plants grew very well in complete culture solutions supplied only with nitrogen from $(NH_4)_2SO_4$ seems to confirm Tiedjens and Robbins' (1931) findings on the same plant, and the work of Hutchinson and Miller's (1909) on a number of agricultural plants.

SUMMARY AND CONCLUSIONS

1. Tomato plants were grown in lakeshore sand supplied with the 3-salt type I solutions, 4-salt type A solutions, and the 4-salt type B solutions, each tried in three different concentrations, and with or without stimulants.

2. For normal growth, in addition to other essential elements, tomato requires NH_4-nitrogen, or a combination of NH_4-nitrogen and NO_4-nitrogen. NO_3-nitrogen alone in complete culture solution seemed not quite suitable or was inadequate for the plant.

3. Under the conditions of this study, 10 p.p.m. of $ZnSO_4$, $Na_2B_4O_7$, and $MnSO_4$ added either singly or in certain combinations to the selected 3-salt and 4-salt solutions of types A and B produced better developed and more productive tomato plants than the cultures that received no stimulants at all.

4. Both of the two most promising culture solutions to add to lakeshore sand contained 3 parts of KH_2PO_4, 9 parts of $(NH_4)_2SO_4$, and 6 parts each of $CaHPO_4.2H_2O$ and $MgSO_4$ with the total concentration of 0.1152 gram-molecule (of all the salts) per liter. One of these contained 10 p.p.m. of $MnSO_4$, and the other 10 p.p.m. each of $ZnSO_4$ and $Na_2B_4O_7$.

5. From 1.75 to 2 liters of the culture solution containing 2 parts of KH_2PO_4, 6 parts each of $(NH_4)_2SO_4$ and $Ca(NO_3)_2$, and 2 parts of $MgSO_4$ with a total concentration of 0.0768 gram-molecule (of all the salts) per liter were enough to bring the tomato plants to maturity. The solution was poured into the sand once a week for seven or eight consecutive weeks at the rate of 250 ml. a plant.

6. Two liters of this culture solution contained 250 ml. of M/1 KH_2PO_4, 750 ml. M/1 each of $(NH_4)_2SO_4$ and $Ca(NO_3)_2$, and 250 ml. of $MgSO_4$, together with the little amounts of the stimulants $ZnSO_4$ and $MnSO_4$ and a few drops of ferric phosphate suspension.

7. To bring the tomato plant to full development and produce ripe fruits required 34.03 grams of KH_2PO_4, 99.11 grams of $(NH_4)_2SO_4$, 177.12 grams of $Ca(NO_3)_2$, and 61.63 grams of $MgSO_4$.

8. The 4-salt type A solution made up of 2 parts of KH_2PO_4, 6 parts each of $(NH_4)_2SO_4$ and $Ca(NO_3)_2$, and 2 parts of $MgSO_4$ with a total concentration of 0.0768 and containing 10 p.p.m. each of $ZnSO_4$ and $MnSO_4$ was found equally suitable for tomatoes grown in sand.

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TABLE 1

Comparison of the nutritive merits of the most promising 3-salt culture solutions

CULTURE NUMBER	MOLECULAR SALT PROPORTIONS KH_2PO_4 $Ca(NO_3)_2$ $MgSO_4$	HEIGHT OF PLANTS	YIELD OF FRUIT	DRY WEIGHT OF ROOTS	DRY WEIGHT OF TOPS	TOTAL CONCENTRATION
						gram-molecule
II	1–3–5	69	20	39	47	0.0279
IV	1–7–1	91 H	57	42	31	
VI	3–3–3	87	0	38	50	
VII	3–5–1	82	71	83	68	
IX	5–3–1	76	31	58	49	
II	2–6–10	80	100 H (157.7 gm.)	42	50	0.0558
IV	2–14–2	90 H	0	40	50	
VI	6–6–6	75	0	43	49	
VII	6–10–2	97 H	0	58	66	
IX	10–6–2	89	100	42	52	
II	3–9–15	100 H (75.5 cm.)	59	81	99 H	0.0837
IV	3–21–3	86	53	37	65	
VI	9–9–9	78	0	87	77	
VII	9–15–3	94 H	0	100 H (7.40 gm.)	100 H (25.98 gm.)	
IX	15–9–3	71	0	57	46	
V	9–3–15	82	85	58	46	

TABLE 2

Comparison of the nutritive merits of the most promising 4-salt type A culture solutions

CULTURE NUMBER	MOLECULAR SALT PROPORTIONS KH_2PO_4 $(NH_4)_2SO_4$ $Ca(NO_3)_2$ $MgSO_4$	HEIGHT OF PLANTS	YIELD OF FRUIT	DRY WEIGHT OF ROOTS	DRY WEIGHT OF TOPS	TOTAL CONCENTRATION *gram-molecule*
III	1–1–5–1	41	0	3	1	0.0384
IV	1–3–1–3	87	2	7	7	
V	1–3–2–2	82	13	17	33	
VI	1–3–3–1	92 H	47	24	47	
VII	1–5–1–1	77	11	18	37	
X	3–3–1–1	78	26	17	26	
III	2–2–10–2	79	47	29	35	0.0768
IV	2–6–2–6	79	73	23	44	
V	2–6–4–4	87	69	28	47	
VI	2–6–6–2	100 H	98 H	29	83	
VII	2–10–2–2	70	12	20	31	
X	6–6–2–2	85	19	48	68	
III	3–3–15–3	91 H	91 H	73	100 H (41.57 gm.)	0.1152
IV	3–9–3–9	92 H	53	45	64	
V	3–9–6–6	100 H (88.1 cm.)	52	69	88	
VI	3–9–9–3	94 H	80	66	95 H	
VII	3–15–3–3	92 H	100 H (394.6 gm.)	100 H (26.89 gm.)	92 H	
X	9–9–3–3	74	87	51	60	

TABLE 3

Comparison of the nutritive values of the most promising 4-salt type B culture solutions

CULTURE NUMBER	MOLECULAR SALT PROPORTIONS KH_2PO_4 $(NH_4)_2SO_4$ $CaHPO_4$ $MgSO_4$	HEIGHT OF PLANTS	YIELD OF FRUIT	DRY WEIGHT OF ROOTS	DRY WEIGHT OF TOPS	TOTAL CONCENTRATION
						gram-molecule
IV	1–3–1–3	69	0	6	7	0.0384
V	1–3–2–2	72	13	16	28	
VI	1–3–3–1	80	15	18	32	
VII	1–5–1–1	90 H	29	23	38	
X	3–3–1–1	77	7	19	31	
IV	2–6–2–6	80	67	38	60	0.0768
V	2–6–4–4	93 H	65	51	62	
VI	2–6–6–2	99 H	45	56	63	
VII	2–10–2–2	84	80	42	55	
X	6–6–2–2	79	18	42	50	
IV	3–9–3–9	95 H	69	61	86	0.1152
V	3–9–6–6	91 H	73	100 H (31.14 gm.)	100 H (47.91 gm.)	
VI	3–9–9–3	100 H (91.5 cm.)	66	70	77	
VII	3–15–3–3	84	100 H (440.5 gm.)	51	76	
X	9–9–3–3	73	82	33	57	

TABLE 4

Comparison of the nutritive values of the most promising 4-salt culture solutions types A and B

CULTURE NUMBER	MOLECULAR SALT PROPORTIONS KH_2PO_4 $(NH_4)_2SO_4$ $Ca(NO_3)_2$[a] $MgSO_4$	TOTAL CONCENTRATION	HEIGHT OF PLANTS	YIELD OF FRUIT	DRY WEIGHT OF ROOTS	DRY WEIGHT OF TOPS
4-salt type A		*gram-molecule*				
VI	2–6–6–2	0.0768	96 H	88	25	72
III	3–3–15–3	0.1152	87	82	63	87
VI	3–9–9–3	0.1152	91 H	70	57	83
VII	3–15–3–3	0.1152	89	90 H	86	80
4-salt type B						
V	3–9–6–6	0.1152	92 H	73	100 H (31.14 gm.)	100 H (47.91 gm.)
VI	3–9–9–3	0.1152	100 H (91.5 cm.)	66	68	77
VII	3–15–3–3	0.1152	84	100 H (440.5 gm.)	51	76

[a] In the 4-salt type B culture solutions, the NO_3 was eliminated. Instead of $Ca(NO_3)_2$, $CaHPO_4.2H_2O$ was used.

TABLE 5

Comparison of the nutritive merits of the most promising 3-salt, 4-salt type A, and 4-salt type B culture solutions

CULTURE NO.	MOLECULAR SALT PROPORTIONS AND STIMULANTS	HEIGHT OF PLANTS	FRESH WEIGHT OF TOPS AND FRUIT	DRY WEIGHT OF ROOTS	NUMBER OF FLOWERS	NUMBER OF FRUIT	WEIGHT OF FRUIT	TYPE OF SOLUTION
I	9–15–3	50	21	30	24	0	0	*gram-molecule*
II	9–15–3 10 p.p.m. $ZnSO_4$	49	25	28	24	28	21	
III	9–15–3 10 p.p.m. $Na_2B_4O_7$	55	28	31	41	0	0	3-salt [a]
VIII	9–15–3 10 p.p.m. $ZnSO_4$ 10 p.p.m. $Na_2B_4O_7$ 10 p.p.m. $MnSO_4$	48	25	27	47	0	0	0.0837
II	2-6-6-2 10 p.p.m. $ZnSO_4$	70	88 H	63	70	57	35	
III	2-6-6-2 10 p.p.m. $Na_2B_4O_7$	70	100 H (265.5 gm.)	60	29	71	100 H (101.4 gm.)	
IV	2-6-6-2 10 p.p.m. $MnSO_4$	84 H	86 H	71	24	28	20	4-salt [b]
VI	2-6-6-2 10 p.p.m. $ZnSO_4$ 10 p.p.m. $MnSO_4$	85 H	97 H	87 H	18	43	48	0.0768
VIII	2-6-6-2 10 p.p.m. $ZnSO_4$ 10 p.p.m. $Na_2B_4O_7$ 10 p.p.m. $MnSO_4$	76	85 H	70	41	71	42	

[a] The 3-salt solutions each consisted of KH_2PO_4, $Ca(NO_3)_2$, and $MgSO_4$.

[b] Each culture solution consisted of KH_2PO_4, $(NH_4)_2SO_4$, $Ca(NO_3)_2$, and $MgSO_4$.

TABLE 5 (continued)

CULTURE NO.	MOLECULAR SALT PROPORTIONS AND STIMULANTS	HEIGHT OF PLANTS	FRESH WEIGHT OF TOPS AND FRUIT	DRY WEIGHT OF ROOTS	NUMBER OF FLOWERS	NUMBER OF FRUIT	WEIGHT OF FRUIT	TYPE OF SOLUTION *gram-molecule*
II	3-9-6-6 10 p.p.m. $ZnSO_4$	83 H	83 H	79	100 H (17)	57	43	
III	3-9-6-6 10 p.p.m. $Na_2B_4O_7$	100 H (87.8 cm.)	81 H	70	24	100 H (7)	58	
IV	3-9-6-6 10 p.p.m. $MnSO_4$	84 H	89 H	74	100 H (17)	100 H	54	4-salt B[c]
V	3-9-6-6 10 p.p.m. $ZnSO_4$ 10 p.p.m. $Na_2B_4O_7$	82 H	86 H	82 H	65	100 H	54	0.1152
VI	3-9-6-6 10 p.p.m. $Na_2B_4O_7$ 10 p.p.m. $MnSO_4$	78	75	100 H (9.86 gm.)	82 H	14	15	

[c] Each culture solution consisted of KH_2PO_4, $(NH_4)_2SO_4$, $CaHPO_2.2H_2O$, and $MgSO_4$.

TABLE 6

Relative values of average data from tomato plants grown in sand supplied with different amounts of a promising 4-salt type A culture solution with an initial total concentration of 0.0768 gram-molecule (of all the salts taken together) per liter with 10 p.p.m. each of $ZnSO_4$ and $MnSO_4$

(Cultures from November 17, 1938, to February 8, 1939)

CULTURE NO.	MOLECULAR SALT PROPORTIONS KH_2PO_4 $(NH_4)_2SO_4$ $Ca(NO_3)_2$ $MgSO_4$	NUMBER OF WEEKLY ADDITIONS OF SOLUTION	AVERAGE HEIGHT OF PLANTS	FRESH WEIGHT OF TOPS	DRY WEIGHT OF ROOTS	NUMBER OF FLOWERS	NUMBER OF FRUIT	YIELD OF FRUIT
I	2–6–6–2 + Zn and Mn	1	55	13	27	8	10	5
II	2–6–6–2 + Zn and Mn	2	70	28	34	37	17	19
III	2–6–6–2 + Zn and Mn	3	82	44	49	42	27	38
IV	2–6–6–2 + Zn and Mn	4	90 H	61	62	41	43	73
V	2–6–6–2 + Zn and Mn	5	89	70	72	43	40	67
VI	2–6–6–2 + Zn and Mn	6	87	75	76	71	60	65
VII	2–6–6–2 + Zn and Mn	7	95 H	82	79	100 H (49)	60	100 H (518.9 gm.)
VIII	2–6–6–2 + Zn and Mn	8	97 H	84	72	86	67	98 H
IX	2–6–6–2 + Zn and Mn	8	92 H	89	90 H	80	50	86
X	2–6–6–2 + Zn and Mn	8	100 H (85.5 cm.)	100 H (399.1 gm.)	89	65	53	93 H
XI	2–6–6–2 + Zn and Mn	8	89	79	55	88	60	78
XII	2–6–6–2 + Zn and Mn	8	94 H	73	69	82	63	91 H
XIII	2–6–6–2 + Zn and Mn	8	95 H	85	100 H (11.81 gm.)	63	100 H (30)	86

COMPARATIVE STUDIES ON THE PLANTING OF BUDDED AND SEEDLING KAPOK [1]

PRUDENCIO O. PACUMBABA

In the Philippines, the kapok plant, [*Ceiba pentandra* (Linn.) Gaertn.][2], is found growing almost everywhere, usually in fences serving as fence posts and along the roadsides as telephone poles. Very little attention has been given to its propagation and culture. It has been propagated usually by seeds and cuttings. No attempt has yet been made to use budded plants in ordinary plantings. In this paper, the results of experiments with budded plants on a large scale are presented.

Ejercito (1926) observed that kapok is propagated by seeds and cuttings, but seed propagation gives better results. Bartolome (1926) reported that kapok is propagated by seeds and cuttings and that seeds give more robust and better plants than cuttings, which produce plants susceptible to the attack of termites. Mendiola (1928), reporting on plants which he brought to the Philippines in 1927 from Java, mentioned that he introduced four living plants of the Surinam kapok and that this variety of kapok was then considered an excellent stock for budding the ordinary kapok. Mercado (1934) mentioned Mendiola's verbal report on experiments of the Central Agricultural Experiment Station of Java on the propagation of kapok by budding and his suggestion that similar work be started here. Following this suggestion, Mercado (1934) started work on kapok budding and later reported that kapok responded to patch budding and grafting readily. He found that the rate of asexual propagation of this plant could be increased about forty times if all the branches were utilized for grafting.

The present work had for its objects: (*a*) the planting of budded kapok plants, (*b*) the planting of kapok seeds at stake under field conditions, and (*c*) the determination of the cost of operations of the different methods of budding.

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[1] Experiment Station contribution No. 1349. Prepared in the Department of Agronomy under the direction of Assistant Professor Pedro A. David.

[2] According to Willis (1931) this is a synonym of *Eriodendron anfractuosum* DC.

The work was performed in the Department of Agronomy from July 30, 1935, to December 30, 1936. The culture of this experiment was made on the College Plateau Plantation of the Department of Agronomy, College of Agriculture, Los Baños.

MATERIALS AND METHODS

In this experiment, about two liters of kapok seeds were used. Two months and two days elapsed from the time of harvesting the kapok pods to the time of planting the seeds. The pods were harvested from the kapok plantation in the Experiment Station of the College.

Preparation of seeds for planting. After the pods were harvested, the seeds were removed, dried, and placed in an air-tight container. Before the seeds were planted, they were first cleaned and soaked in water for eighteen hours. Those that sank after having been soaked for eighteen hours were used for planting, whereas those that did not were discarded.

Nursery. Four plots, 1 by 4 meters each, were prepared. The soil in each was forked and pulverized thoroughly and levelled with a rake. Each plot was divided into 40 rows across, 10 centimeters apart. In each of the rows, 20 seeds were sown about two centimeters deep. Then they were covered with a thin layer of surface soil. The seedlings were pricked when they were about a month old and planted 10 by 15 centimeters apart in nursery plots which had been previously prepared. Four hundred and sixty-two of these seedlings were budded, 49 by patch budding, 96 by shield budding, and 317 by patch-shield budding.

Budding

Budding was done both in the morning and in the afternoon, but most of the work was done in the afternoon. In this experiment, three methods of budding were used. These are described as follows:

Shield budding. At a point on the stem of the stock about thirty centimeters above the ground, a vertical cut about three to four centimeters long was made with a sharp budding knife through the bark as deep as the cambium layer. By slightly tipping the sharp edge of the knife blade upward, a horizontal cut was made at the lower end of the vertical cut so that the wound appeared like an inverted T. In order to facilitate the insertion of the scion, the bark was loosened just sufficiently to slip the bud easily into place by a slight upward twist of the knife blade in the vertical cut. The bud was cut not less than two centimeters long, including the woody portion forming the bud stick. Then the bud was tied firmly with a piece of budding tape but not so tightly as to crush the bud. The tying of the newly inserted bud was begun at the point of the insertion upward, and the bud was left exposed.

Patch budding. On the stock about thirty centimeters above the ground, a rectangular cut about one centimeter wide and two to two and one-half centimeters long was made through the bark to the woody portion. The bark was removed and the woody portion left exposed. Then a piece of bark containing a bud was removed from the budstick. The removed bark containing a bud was made rectangular in shape and a little smaller than the size of the wound in the stock. The bud was inserted in the normal position in the cut on the stock and tied firmly with budding tape; the bud was left exposed to the atmosphere.

Patch-shield budding. In this method the same operation as that in ordinary shield budding was used, except that in the case of the scion, after the bud had been removed from the budstick, the woody portion was removed by inserting the point of the knife blade between the bark and the wood. In this case, no woody portion was included in the scion when it was inserted in the cut or wound of the stock. The tying was begun at the point of insertion and continued upwards with the dormant bud left exposed. Then the growing point of the stock was cut or removed just after budding.

The formula used for the preparation of budding tape is one part beeswax, one part resin, and one part tallow. The knife used for budding was the ordinary Remington three-blade knife.

The budsticks were taken from kapok trees growing in the College of Agriculture kapok plantation. These trees are selected as sources of budsticks for their high yielding ability as shown in the record book of the Department of Agronomy. The budsticks were taken only from horizontal branches. Both blunt and pointed buds were used for budding. The stocks at the time of budding were from 1.5 to 2 cm. in diameter.

The cost of budding was based on the amount of budding tape consumed, the depreciation of the knife used, and the time spent for labor.

Observations on budding. Patch and shield budding were the methods used in budding the seedlings in the nursery. These two practices were never used in budding the plants in the field. "Patch-shield" budding was the only system used in budding the seedlings planted in both the field and the nursery because, previous to this undertaking, the writer had performed some preliminary experiments on the three methods. This was done for the purpose of finding out just which would give the highest percentage of success in budding the plants both in the nursery and in the field.

About two weeks after budding, the scions were examined and their conditions were noted. At this time the inserted buds were considered successful if they were still green. When a bud was found green, the main stem of the stock was cut off at a point about twenty centimeters above the budded portion, and all the side shoots found on the portion left were removed. When the bud was about three centimeters long, the remaining stem was cut slantingly with the higher portion just above the growing bud. The wound was coated with asphalt dissolved in kerosene.

When the buds were about ten centimeters in height, they were transplanted to the permanent field. At the end of the experiment, the length of the buds was measured and the number of leaves produced was counted. The unbudded plants both transplanted and planted at stake were measured, and the number of leaves was also counted.

After the seeds had been planted both in the nursery and in the field, observations were made to determine the number of days required from sowing to germination of the seeds. Each day that the seeds germinated, they were counted. All those that germinated in each row were recorded separately. When the seedlings were about a year old, they were budded as described under budding. The number of living buds was recorded. Those seedlings that were planted in the nursery were transplanted in the permanent field when they were about a year old. The budded seedlings in the nursery were transplanted when the growing buds were about ten centimeters long, and the budded plants and seedlings planted at stake were thinned to one plant per hill about forty days after budding. The measurement of the growth of the buds at the end of the experiment was made from the point where the scion was inserted to the growing point of the bud. At the end of the experiment, the total number of visible leaves which developed on each inserted scion was also recorded. The measurement of the total growth of the seedlings, both transplanted and planted at stake, was from the base to the highest vertical growing point of the plant. The total number of leaves which developed from each seedling was also recorded at the end of the experiment.

Layout of the field

The area of the land used was 15,516 square meters. The field was cleared by cutting down the shrubs and grasses in the dry season and then drying and burning them. The land was staked six by six meters in quincunx arrangement. The soil, for about thirty centimeters radius around the stakes, was forked and pulverized. Three to five seeds were planted near the base of the stakes. When the seedlings were about a month old, they were thinned to three to a hill. Those pulled up were utilized for replanting vacant hills. At the age of about one year, all the seedlings in the field were budded alternately in the row. Those raised in the nursery and the kapok plants budded there were transplanted alternately between the rows of the kapok planted at stake. Forty days after budding in the field, the budded plants and the seedlings planted at stake were thinned to one plant per hill.

Care of the plantation

The plants planted at stake and the "nursed" ones were cultivated whenever necessary. The care given was the same in all treatments.

EXPERIMENT AND RESULTS

The results of observation on length of time and percentage of germination are given in tables 1 and 2.

The percentages of success obtained with the three methods of budding and the computed cost per 100 budded plants are presented in tables 3, 4, 5, and 6.

The detailed measurements of the growth and number of leaves produced were taken at the end of the experiment. These data were recorded in the Department of Agronomy Record Books and summarized in tables 7, 8, and 9.

At the end of 498 days, the living plants, budded and unbudded, were recorded and the results presented in table 10, which gives the percentage of stand or living plants at the end of the experiment.

DISCUSSION OF RESULTS

Total number of days from planting to germination

The seeds planted in the nursery and in the field did not germinate at the same time. They began to germinate on the fifth day after planting and ended on the ninth. Table 1 shows that the mean total number of days from planting to germination of the seeds sown in the nursery was less than that in the field, although there was no significant difference.

Percentage of germination

Of the 3,200 seeds planted in 160 nursery rows, at the rate of 20 seeds a row, the range of germination was found to be 6 to 20 per row, and equivalent to 30 to 100 per cent (table 2). The seeds that germinated from each hill were from 0 to 5 or from 0 to 100 per cent. It was clearly evident that the seeds sown in the nursery had a significantly better germination than those planted at stake.

Percentage of successful buds and the computed cost per 100 buddings

Table 3 shows that, of the three different methods of budding used in this experiment, patch-shield gave the best results. Of the 560 seedlings budded by the patch-shield method, 530 buds were found successfully growing after three weeks from the time they were inserted. There was, therefore, 94.6 per cent success. Of 96 shield-buddings in the nursery, none grew. Patch budding, however, was 2.04 per cent successful. This is low compared with the percentage of success obtained in patch budding by Mercado (1934), who reported 89 per cent success. This difference might be due to the skill of the individual who performed the work as well as to the time of budding.

The cost of budding by the three methods herein employed is shown in table 4. It is clearly seen that although both shield and patch buddings were performed in the nursery, the latter cost more than the former; the difference was ₱0.299 per 100 budded plants in favor of shield budding, but this advantage is offset by patch budding as kapok does not seem to respond to shield budding. Patch-shield budding, however, as shown in table 4, cost much less than patch budding, although a little more than shield budding. The difference in cost between patch budding and patch-shield budding was ₱0.278 in favor of patch-shield for every 100 plants. Aside from this advantage, the patch-shield method of budding kapok was found to be 94.6 per cent successful.

It may be seen from table 5 that an average of 95.53 per cent or 304 of the total 317 buds inserted were successful in the nursery, whereas in the field, only 92.37 per cent, or 226 of the total of 243 scions, developed. If the cost of budding with the patch-shield method in the nursery is compared with that in the field, budding in the field is more expensive. It cost ₱1.347 to insert 317 buds in the nursery, (table 6) and ₱1.54 to insert 243 plants in the field. The computed cost of budding 100 plants in the nursery was ₱0.425, whereas in the field it was ₱0.634. The difference is ₱0.209 for every 100 plants in favor of budding in the nursery.

Comparison of transplanted buds, budded in the nursery and in the field

Measurements of the length of buds, budded in the nursery and transplanted in the permanent field, and the corresponding number of leaves produced were made at the end of the experiment. These measurements which are recorded in the Department of Agronomy are summarized in table 7. It was found that the growth of buds was variable. The range was from 8.5 centimeters to 240.3 centimeters. The mean growth of buds on 99 individuals was 51.9 ± 2.1 centimeters for 4 months and 18 days. The number of leaves produced was also very variable. The range was from 15 to 350 leaves as recorded, and the mean number of leaves produced was 66.0 ± 4.1 in 4 months and 18 days.

The growth of buds budded in the field was also variable. The range of growth was from 15.5 to 190 centimeters, and the mean growth of the buds was 67.0 ± 2.4 centimeters after 4 months and 18 days (table 7). The range in the number of leaves produced was from 18 to 229 and the mean number was 69.8 ± 2.9.

A comparison of the growth of the buds budded in the field with that of those budded in the nursery and transplanted clearly shows that the plants in the field made significantly better growth in length than those budded in the nursery and transplanted. In mean number of leaves produced, there was an insignificant difference.

Comparison between the unbudded plants planted at stake and the transplanted ones

The range of height of the transplanted plants 498 days after the seeds had been planted, was from 142.2 to 342.6 centimeters, and the range of the number of leaves produced was from 79 to 536 leaves. The range of the height of the plants planted at stake was from 106.4 to 458.3 centimeters, whereas the number of leaves produced was from 94 to 885, (table 8). The mean height of the plants planted at stake was significantly greater than that of the transplanted plants. The mean number of leaves produced by the plants planted at stake was also significantly greater than that of the transplanted plants. Results obtained from this experiment show that the plants sown in the field were taller and produced more leaves than the transplanted ones.

Comparison between the budded plants and the unbudded ones

Table 9 shows that the unbudded plants are very much taller than the budded, and the difference between their mean heights is significant. The unbudded plants produced significantly more leaves than the budded. It is seen from table 9 that unbudded plants are better in both characters studied than the budded ones.

Percentage of stand in the field

Table 10 shows the percentage of stand of the plants at the end of the experiment. The seeds planted at stake gave 97.2 per cent. At the end of the experiment, 105 plants lived out of 108 planted in the field. From 101 plants transplanted, 96 or 95.1 per cent, lived. Of the 110 transplanted budded plants, 99 or 90 per cent, were living at the end of 498 days. Out of the 112 budded plants in the field, 100 plants or a percentage stand of 89.3, were found living at the end of the experiment. The plants planted in the field gave the highest percentage of success, and the budded plants in the field, the lowest.

SUMMARY AND CONCLUSION

An attempt was made to study the planting of kapok seeds at stake and budded kapok plants under field conditions, and to determine the cost of operation in three different methods of budding. Results thus far obtained may be summarized as follows:

1. Neither in the field nor in the nursery did the seeds germinate at the same time. It took from 5 to 9 days from planting for the seeds to germinate.

2. The seeds planted in the nursery gave better germination than those planted at stake.

3. Patch-shield budding gave a better percentage of success than shield and patch budding under field conditions. It was cheaper to bud kapok by the patch-shield method than by patch budding only.

4. There was not much difference in the average percentage of success between the plants budded in the nursery and those budded in the field by the "patch-shield" method. Budding in the nursery, however, cost much less than in the field.

5. The plants budded in the field were taller than the transplanted plants, but they produced practically the same number of leaves.

6. The seedlings planted directly in the field were more vigorous and produced more branches and leaves than the transplanted ones.

7. The unbudded seedlings grew better and produced more leaves than the budded plants.

8. Seedlings planted directly in the field gave a high percentage of success and budded plants a low percentage.

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TABLE 1

Comparison between the mean number of days from planting to germination in the nursery and in the field

TREATMENT	MEAN NUMBER OF DAYS FROM PLANTING TO GERMINATION	RANGE
		days
Seeds sown in the nursery (154)	6.90 ± 0.02	5 — 9
Seeds planted at stake (616)	6.97 ± 0.02	5 — 9
Difference	0.07 ± 0.03	

TABLE 2

Comparison of the percentage of germination of the seeds sown in the nursery with the seeds planted at stake

TREATMENT	MEAN PERCENTAGE OF GERMINATION	RANGE OF GERMINATION	
		seeds	*per cent*
Seeds sown in the nursery	70.6 ± 0.88	6 — 20	30 — 100
Seeds planted at stake	57.1 ± 0.98	0 — 5	0 — 100
Difference	13.5 ± 1.59		

TABLE 3

Percentage of living buds

CHARACTER NOTED	METHODS OF BUDDING		
	Patch [a]	Shield [a]	Patch-shield
Number of inserted scions	49	96	560
Number of green or developing buds	1	0	530
Percentage of developing buds	2.04	0	94.6
Number of hours spent in budding	3.5	4	24.5

[a] Patch and shield buddings were the methods used in the nursery, whereas patch-shield budding was used both in the nursery and in the field.

TABLE 4

Cost of budding by the three different methods

METHODS	NUMBER OF PLANTS BUDDED	COST OF BUDDING	COMPUTED COST OF BUDDING PER 100 SEEDLINGS
		pesos	*pesos*
Patch budding	49	0.388	0.793
Shield budding	96	0.475	0.494
Patch-shield budding	560	2.888	0.515

TABLE 5

Percentage of success in budding both in the nursery and in the field by patch-shield method

DATE OF BUDDING	BUDDING IN THE NURSERY			BUDDING IN THE FIELD			NUMBER OF HOURS SPENT IN BUDDING	
	Number of inserted scions	Number of living buds	Percentage of success in budding	Number of inserted scions	Number of living buds	Percentage of success in budding	Nursery	Field
1936								
July 18	78	75	96.15				2.5	
July 19	99	95	95.96	54	50	92.59	3.0	3.0
July 21				69	66	95.65		3.5
July 22	54	54	100.00				2.0	
July 23				30	28	93.33		2.0
July 24	35	32	91.43				1.5	
July 25				55	52	94.55		3.0
July 26	51	48	94.12	35	30	85.71	2.0	2.0
Total	317	304		243	226		11.0	13.5
Average			95.53			92.37		

TABLE 6

Cost of budding in the nursery and in the field

PATCH-SHIELD BUDDING	NUMBER OF PLANTS BUDDED	COST OF BUDDING	COMPUTED COST OF BUDDING FOR 100 PLANTS
		pesos	*pesos*
Nursery	317	1.347	0.425
Field	243	1.540	0.634

TABLE 7

Comparison of the growth of transplanted buds, budded in the nursery and in the field; and the number of leaves of each

TREATMENT	MEAN LENGTH OR GROWTH OF BUDS	MEAN NUMBER OF LEAVES PRODUCED	RANGE IN	
			Growth of buds	Leaves produced
	cm.		*cm.*	*number*
Seeds planted at stake and then budded (100)	67.0 ± 2.4	69.8 ± 2.9	15.5 — 190.0	18 — 229
Seeds sown and budded in the nursery and transplanted (99)	51.9 ± 2.1	66.0 ± 4.1	8.5 — 240.3	15 — 350
Difference	15.1 ± 3.1	3.8 ± 5.0		

TABLE 8

Comparison between the heights of unbudded plants planted at stake and the transplanted ones; and the number of leaves of each

TREATMENT	MEAN HEIGHT OF THE PLANT	MEAN NUMBER OF LEAVES PRODUCED	RANGE IN	
			Height of seedlings	Leaves produced
	cm.		*cm.*	*number*
Seeds planted at stake (105)	240.1 ± 4.7	293.5 ± 9.2	106.4 — 458.3	94 — 885
Seeds sown in the nursery and transplanted in the field (96)	210.6 ± 2.9	221.7 ± 6.1	142.2 — 342.6	79 — 536
Difference	29.5 ± 5.5	71.8 ± 11.0		

TABLE 9

Comparison between the growth of the budded plants and the unbudded ones, and the number of leaves of each

TREATMENT	MEAN LENGTH OR GROWTH OF BUDS	MEAN NUMBER OF LEAVES PRODUCED
	cm.	
Budded plants (199)	59.5 ± 2.2	67.9 ± 3.0
Unbudded plants (201)	225.4 ± 3.4	257.6 ± 7.6
Difference	165.9 ± 4.1	189.7 ± 8.2

TABLE 10

Percentage of stand of the plants in the field at the end of the experiment

TREATMENT	NUMBER OF LIVING PLANTS AT THE BEGINNING OF THE EXPERIMENT	NUMBER OF LIVING PLANTS AT THE END OF THE EXPERIMENT	PERCENTAGE OF STAND IN THE FIELD
Seeds planted at stake .	108	105	97.2
Seeds sown in the nursery and seedlings transplanted in the field	101	96	95.1
Seeds sown and seedlings budded in the nursery and transplanted in the field ..	110	99	90.0
Seeds planted and seedlings budded at stake .	112	100	89.3

PHYSIOLOGICAL STUDIES ON POULTRY: IV. OBSERVATIONS ON THE NORMAL HEMOGLOBIN CONTENT OF THE BLOOD OF LOS BAÑOS CANTONESE CHICKEN [1]

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WITH ONE CHART

Studies on the hematology of several breeds of cattle carried out in this College showed that the hemoglobin content of the blood may be used as a guide in evaluating the adaptability of different breeds to a given set of environmental conditions (Manresa and Reyes, 1934). On this premise, it was thought interesting to find out if a similar condition holds true in the case of poultry. As a preliminary step, therefore, these observations were undertaken in the Poultry Division of the Department of Animal Husbandry from June to October, 1939 with the following objects: (*a*) to determine the best time of the day for drawing blood samples for hemoglobin determinations, (*b*) to determine the normal hemoglobin content of the blood of the Los Baños Cantonese, and (*c*) to find out if any fluctuations due to sex, hour of sampling, body temperature, and atmospheric temperature occur.

Review of literature

According to Dukes (1937), "the amount of hemoglobin in the blood is influenced by such factors as age, sex, season, life habits of the species, and disease". He reported that the normal hemoglobin content of the blood was 13.5 grams per 100 cc. in the cock and 9.8 grams per 100 cc. in the hen. No specific breed was mentioned.

In a study made of two groups of 8-week-old Rhode Island Red chickens, Olson and Levine (1939) found the hemoglobin index to range from 10.6 to 9.8 grams per 100 cc. in the control or normal lot.

Working on Nellore cattle, Manresa, Gomez, and Santos (1939) reported that the most uniform reading at intervals of four hours throughout the entire day was obtained at 10:00 o'clock in the evening. They further added that as the hemoglobin reading was to a slight extent correlated negatively with the atmospheric temperature, it was not likely that a specific time of the day could be found in which samples of the blood would give regularly uniform results.

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[1] Experiment Station contribution No. 1350. Read before the Los Baños Biological Club, Dec. 14, 1939.

Plan of the study

Los Baños Cantonese chickens—ten roosters and ten hens—of approximately the same age and condition were used in this study. They were picked at random from the College flocks which were under identical care, feeding, and management.

The birds were brought in from the pens to the laboratory and placed in exhibition cages. They were fed the normal College ration and supplied with water at all times. Hemoglobin indices as well as body and atmospheric temperatures were taken at four-hour intervals for twenty-four consecutive hours. After this period, the birds were returned to their respective pens. One week was allowed to elapse before another similar determination was made on the same birds. This was to minimize any possible effects that long confinement might introduce in subsequent determinations. Three such 24-hour determinations were made.

Blood samples for the hemoglobin determination were drawn at 6 and 10 o'clock in the morning; at 2, 6, and 10 o'clock in the evening; and at 2 and 6 o'clock in the morning of the following day. Blood was drawn by pricking a point of the comb and the hemoglobin index determined by the improved method of Newcomer. Three blood samples were taken from each bird each time, and their average was considered the value for the determination.

The body temperature by the rectum was determined for the same hours with an "S. L. Standard" veterinary thermometer. The thermometer was held in the rectum, about five centimeters deep, for not less than three minutes. The atmospheric temperature was recorded by means of an ordinary laboratory thermometer.

To show if the birds suffered any loss in body weight owing to confinement and handling, they were weighed before and after each twenty-four-hour period of observation.

RESULTS AND DISCUSSION

Body weights. The birds apparently suffered a little from the twenty-four-hour confinement and handling which was repeated thrice with one week interval between each confinement. From the body weights recorded before and after each twenty-four-hour period, the roosters were found to have lost an average of 16 ± 91 grams, or 0.82 per cent of their average live weight. The hens on the other hand lost more, 74 ± 60 grams, or 4.76 per cent of their live weight. These losses are insignificant. The hens in all three observations, however, showed consistent loss in body weight during each twenty-four-hour period. This was not true in the case of the roosters.

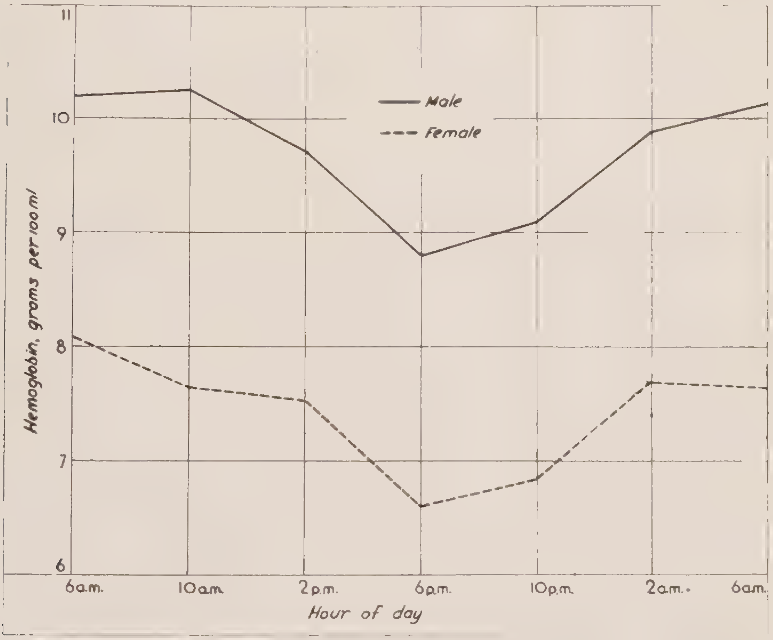

Chart 1.—Showing the normal fluctuations of the hemoglobin content of the blood of Los Baños Cantonese chickens.

Hemoglobin. The means of the hemoglobin indices of both males and females for the three different sets of determinations at four-hour intervals with their corresponding standard deviations and coefficients of variation are presented in table 1. The means are illustrated in chart 1.

It can be seen that the hemoglobin indices for the roosters were consistently higher than those for the hens throughout the twenty-four-hour period. The mean hemoglobin index for the rooster was 9.72 ± 0.16 grams per 100 ml. of blood, while that of the hen was only 7.42 ± 0.13; a highly significant difference of 2.30 ± 0.21 grams per 100 ml. These figures are very much lower than those reported by Dukes (1939) for the normal cock and hen. These differences may be due to differences in the breed and environmental factors.

The hemoglobin indices were found to be very variable among the different individuals at a given hour. The hens had a higher coefficient of variability, a mean of 8.49 per cent with a range of 13.10 to 6.57 per cent, than the roosters with a mean of 6.89 per cent and a range of 10.85 to 4.98 per cent. They were, however, consistently high in the morning at 6:00 o'clock and low in the evening at the same hour.

Examination of table 1 shows that the roosters and the hens had a lower hemoglobin index at the end of the twenty-four-hour period than at the beginning, a greater difference existing in the case of the hens. This difference, however, of 0.45 ± 0.286 grams per 100 ml. is insignificant when statistically treated.

The higher variability of hemoglobin in hens than in roosters and the apparent difference in the readings at the beginning and at the end of the twenty-four-hour periods might be ascribed to the fact that the hens are generally of a more excitable nature than the roosters, i.e., the hens suffer more from the confinement and handling than the roosters. This is more apparent when the difference in loss of body weight discussed previously is considered.

The hemoglobin index was found to be most uniform in samples taken at 10 o'clock in the morning from the roosters and at 10 o'clock at night from the hens, and least uniform in those taken at 6:00 a.m. from the roosters and at 10 a.m. from the hens. If, however, the hour of sampling at which the hemoglobin reading is closest the mean for the day is considered, then it may be stated that 2:00 o'clock in the afternoon is the best time of the day to draw blood samples for hemoglobin determination in chickens, inasmuch as, if samples are taken at that hour, these samples will be nearest the mean for the day. This was found to hold true in both males and females.

Body and atmospheric temperatures. The mean of the body temperatures of both hens and roosters for the three sets of determinations, with their respective standard deviations and coefficients of variation and the corresponding atmospheric temperatures, are presented in table 2.

From table 2 it may be seen that the roosters had a lower mean body temperature, 41.3 ± 0.03°C., than the hens, 41.5 ± 0.04°C. This difference is significant when treated statistically.

The lowest normal body temperature of the Los Baños Cantonese chicken was found to occur at 10 o'clock at night while the highest occurred during the day from 6 o'clock in the morning to 2 o'clock in the afternoon. Fronda (1925) observed that the minimum normal body temperature of a chicken occurred from 10:00 to 12:00 o'clock at night, while the maximum occurred sometime in the afternoon. He also added that the body temperature began to rise at 2:00 o'clock continuing quite steadily until 8:00 o'clock in the morning when the increase was gradual until the maximum was reached sometime in the afternoon.

The body temperature was found to be less uniform during the night and less variable during the day. As a whole, in both hens and roosters, the body temperature was found to be less variable than the hemoglobin indices.

Examination of table 2 will show that there seems to be no consistent relationship between the body and the atmospheric temperatures. Manresa, Gomez, and Santos (1939), in a study involving ten Indian Nellore cattle, concluded that body temperature and atmospheric temperature were positively correlated, the correlation coefficient being moderately high and significant. In a study of various breeds of chickens, however, where the body and atmospheric temperatures were taken at two-hour intervals for forty eight consecutive hours, Fronda (1925) concluded that the temperature of the room did not have any apparent effect upon the body temperature of the chicken.

Hemoglobin and body temperature. Manresa, Gomez, and Santos (1939), working on Indian Nellore cattle, found that the hemoglobin reading was to a slight extent correlated negatively with the atmospheric temperature. And, as they found the atmospheric and body temperatures positively correlated, then, the same relationship may be said to exist between hemoglobin and body temperature. In this study, statistical treatment of the data showed the presence of only a low negative correlation coefficient, –0.134 ± 0.176, which is of no significant value.

SUMMARY AND CONCLUSIONS

1. The mean hemoglobin index of the Los Baños Cantonese rooster was found to be 9.72 ± 0.16 grams per 100 ml. of blood, while that of the hen was 7.42 ± 0.13.

2. Hemoglobin indices were very variable during a twenty-four-hour period, but were consistently high in the morning at 6:00 o'clock and low at the same hour in the afternoon.

3. Most uniform samples for hemoglobin determination were obtained at 10 o'clock a.m. for the roosters and at 10 o'clock p.m. for the hens. Readings nearest the means, however, were obtained at 2 o'clock p.m. in both roosters and hens.

4. The mean body temperature for the Los Baños Cantonese rooster was found to be 41.3 ± 0.03°C. and 41.5 ± 0.04°C. for the hen, the difference between the two being significant.

5. There seems to be no relationship between the hemoglobin content of the blood and the body temperature in the Los Baños Cantonese, a low negative correlation coefficient of no significant value having been obtained in this study.

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TABLE 1

Hemoglobin content of the blood of Los Baños Cantonese chickens, grams per 100 ml.

HOUR OF DAY	MALES			FEMALES		
	Mean	S. D.	C. V.	Mean	S. D.	C. V.
6 a.m.	10.18 ± 0.22	1.00	9.82	8.07 ± 0.21	0.94	11.64
10 ”	10.24 ± 0.13	0.51	4.98	7.63 ± 0.14	1.00	13.10
2 p.m.	9.71 ± 0.19	0.87	8.95	7.53 ± 0.13	0.53	7.04
6 ”	8.79 ± 0.15	0.73	8.30	6.59 ± 0.11	0.44	6.68
10 ”	9.08 ± 0.16	0.74	8.14	6.84 ± 0.11	0.45	6.57
2 a.m.	9.88 ± 0.18	0.82	8.29	7.68 ± 0.18	0.82	10.68
6 ”	10.14 ± 0.24	1.10	10.85	7.64 ± 0.20	0.88	11.52
Mean for day ..	9.72 ± 0.16	0.67	6.89	7.42 ± 0.13	0.63	8.49

TABLE 2

Body temperatures of Los Baños Cantonese chickens and atmospheric temperatures, °C.

HOUR OF DAY	MALES			FEMALES			ATMOSPHERIC TEMPERATURES
	Mean	S. D.	C. V.	Mean	S. D.	C. V.	
6 a.m.	41.7 ± 0.06	0.28	0.67	41.5 ± 0.04	0.17	0.41	26.3
10 ”	41.2 ± 0.04	0.17	0.41	41.6 ± 0.04	0.17	0.41	27.7
2 p.m.	41.4 ± 0.04	0.14	0.34	41.8 ± 0.05	0.22	0.53	28.7
6 ”	41.2 ± 0.06	0.32	0.78	41.3 ± 0.06	0.95	2.30	27.5
10 ”	40.7 ± 0.06	0.41	1.01	41.2 ± 0.07	0.54	1.31	26.7
2 a.m.	41.2 ± 0.04	0.22	0.53	41.6 ± 0.06	0.28	0.67	25.8
6 ”	41.5 ± 0.04	0.17	0.41	41.5 ± 0.04	0.20	0.48	26.4
Mean for day .	41.3 ± 0.03	0.14	0.34	41.5 ± 0.04	0.17	0.41	27.0

A STUDY OF SOME ASEXUAL METHODS OF PROPAGATION OF THE STAR APPLE, CHRYSOPHYLLUM CAINITO LINN.[1]

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There are many forms of the star apple but no named varieties although some of these are of exceptional qualities and are worth perpetuating. The plants when grown from seeds are rather variable, and for purposes of improvement an effective method of asexual propagation should be found. It is for this reason that this study was conducted.

Padolina (1929) reported that the plant may be grown by marcottage although the marcots do not form roots readily. Fraser (1931), Popenoe (1934), and Mowry, et al. (1936) are of the belief that the plant may be budded, although no report of actual trials was made.

Shield budding with fairly mature brownish to greenish, non-petioled budwood, cut 3.5 to 4 centimeters long and inserted in the stocks at a point of approximately the same appearance as the scions, was recommended by Wester (1920). Gonzalez (1934) did not succeed in shield budding the star apple, but he reported having obtained successful results in inarching, marcotting, and bark grafting. Padolina (1929) reported that in 1924 the star apple was successfully grafted on the caimitillo, *Chrysophyllum oliviforme* Lam., but no details of the method used were given. Gonzalez (1934) was also able to induce union between the two plants by the graftinarching method, but the star apple grafts, now five years old, although quite healthy, have not shown signs of flowering.

Fraser (1931), Popenoe (1934), and Reasoner (Bailey, 1937) believe "that the star apple may be grown from cuttings if they are prepared from well ripened shoots placed over strong, moist heat." In this connection Ilarina (1930)[2] tried different methods of inducing star apple cuttings to root, including treatment with potassium permanganate solutions and application of bottom heat, but he was not successful in rooting them.

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[1] Experiment Station contribution, No. 1351.

[2] Ilarina, E. I. Propagation of certain fruit plants by stem cuttings with special reference to the use of the bottom heat. (Thesis presented for graduation from the College of Agriculture with the degree of Bachelor of Science in Agriculture. 1930. Unpublished.)

From the result of the search by the writers for literature, it seems justifiable to conclude that available information on the star apple is rather fragmentary and a detailed report on the subject of asexual methods of propagation of this fruit plant is almost wanting.

The object of the present work was to test the adaptability of certain methods of asexual propagation to the star apple.

The work herein described covered a period of fourteen months from May, 1938, to June, 1939. It was conducted in the nurseries and orchards of the Department of Agronomy of this College.

MATERIALS AND METHODS

Materials

Stocks. The stocks used for inarching were star apple plants grown from seeds collected from the College orchard. The seedlings were potted at the age of two months and transferred to larger pots six months later. At the age of ten months they were wrapped in fiber of cabonegro plant, *Arenga pinnata* (Wurmb) Merr., allowed to recover from the effects of the transfer, and used for inarching when they were approximately one year old, at which time they were about thirty-five centimeters in height.

The stocks used in shield budding and cleft grafting were star apple seedlings obtained from the same trees but grown one year earlier than those used for inarching. They were potted as described above and, when they were about one year old, they were planted about sixty centimeters apart in nursery rows, one-hundred and fifty centimeters apart.

Scions. The scions for inarching, cleft grafting, and shield budding were secured in the College orchard from five selected trees from ten to twenty-five years old.

Budding tape and grafting wax. The budding tape used was made from cheese cloth dipped in a melted mixture of 4 parts resin, 4 parts beeswax, and 1 part tallow. For grafting wax, a mixture of 4 parts resin, 2 parts beeswax, and 1 part tallow was used.

Sphagnum moss. Moist sphagnum moss was used as the material for covering the grafts in cleft grafting. The moss was bought from a flower nursery in Manila. It was of good quality and was said to have come from Haights Place, Mountain Province.

Materials for marcotting. The branches for marcotting were secured from some trees bearing normally but whose fruit was not necessarily of a choice kind. It was feared that the trees would be adversely affected by the removal of so many branches; hence non-selected trees were used.

The soil used for wrapping the ringed branches in marcotting came from the orchard and was classified by Dr. N. Galvez of the Department of Soils of this College as "Ibaan clay loam". Pounded coconut husk was used in covering and keeping the soil in place on the marcotted branches. Number 16 wire was used in tying the coconut husk in place.

Auxin solutions of two kinds, Hormodin A and Auxilin, were used for inducing root production in marcottage; Hormodin A is prepared for sale by Merck and Co., Inc., Rahway, N. J., while Auxilin is prepared by Pennsylvania Chemical Corporation, 76 Beaver Street, New York, N. Y. The preparations were obtained from Botica Boie, Escolta, Manila, by Professor H. Cuzner of the School of Forestry, University of the Philippines, and donated for trial in this experiment.[3]

Other materials used in the experiment included budding knives, labels, absorbent cotton, and Manila and oil papers.

Selection and preparation of materials

Selection of stocks. Only vigorous, healthy looking plants were selected and used for stocks. Those used for inarching were one year old and about eight-tenths of a centimeter in girth. Those for shield budding and cleft grafting were two years old and about two centimeters in girth.

Preparation of stocks for shield budding and cleft grafting. The seedlings selected for stocks were pruned to a single stem, kept well cultivated in the nursery rows, and liberally watered whenever necessary. Surface dressing of decayed horse manure was applied from time to time to insure good growth of the seedlings.

Selection of scions. The scions were taken from five healthy trees whose fruit was of excellent quality. Only strong, vigorous branches with prominent buds were selected. In all studies care was taken that the same number of scions from each tree were included in each lot.

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[3] The writers are grateful to Professor H. Cuzner for his donation of several bottles of the auxin preparations used in this experiment.

Preparation of scions for shield budding. The scions used were of three kinds: young, intermediate, and old. The young buds were obtained from the newly developed branches. The buds were very tender in texture and were brownish orange in color. The old buds were secured from the old branches. These buds were gray and harder in texture than the young buds. The intermediate buds were brown, secured from mature but not yet old, branches.

Two ways of preparing the shields were used. In one, a thin layer of wood was left attached to the bark as in ordinary shield budding and, in the other, the wood was removed from the bark as in patch budding.

Preparation of scions for cleft grafting. The scions used in this experiment were classified into three groups according to age; young, medium, and old. Young scions were secured from newly developed branches. They were characterized by being somewhat tender and having a brownish orange color. They were usually small, about one-half of a centimeter in diameter. The intermediate ones were brownish and the old scions were gray. Both old and intermediate scions were of hard wood.

The selected budwoods from each group were prepared in three ways. Some of them were inserted soon after they were cut from the mother trees, some were defoliated in the tree two weeks before the insertion took place, and some were cut and placed in moist sand one week before being used as scions.

Selection of branches for marcottage. The branches were classified according to their sizes: small, medium, and large. Branches belonging to the small size had a diameter of about two centimeters, medium four centimeters, and large about six centimeters. In all cases, only healthy branches were marcotted. An equal number of branches from each tree was included in each group.

Preparation of auxin solutions. The auxin solutions used in marcottage were prepared according to the directions given by the manufacturers. Three kinds of solutions were prepared, namely, an Auxilin water solution, a 20-unit Hormodin water solution, and a 40-unit Hormodin water solution.

Asexual methods of propagation employed

Marcottage. Each of the selected branches to be marcotted was girdled, a ring of bark about seven centimeters long being removed. After being girdled, some of the branches were immediately covered with soil, others exposed for ten days before being covered, and some were treated with auxin solutions for 24 hours before the covering was placed.

After the bark of the branches to be treated with auxin solutions had been ringed, a piece of absorbent cotton soaked in the auxin solution was wrapped around the incision. To prevent rapid evaporation of the solution and to keep it from being washed away by rain, the treated part was enclosed in a piece of thin oil-paper about twenty centimeters wide and thirty centimeters long. Both ends of the paper were tied with string. This was covered again with a piece of Manila paper. The treated branch was allowed to remain in this condition for twenty-four hours, after which the cotton was removed and the incision washed with water to remove excess solution.

For the rooting medium, a sufficient quantity of soil was used. This was kept compact around the ringed portion of the branch and held secure by pieces of well pounded coconut husk tied firmly with fine wire. The marcotted branches were properly labeled and, thereafter, watered regularly until they could be severed from the mother plants. After being severed, the marcots were planted in kerosene cans with perforations at the bottom, for drainage. Planting was done with care so that the roots were not injured. The leaves of the marcots were pruned in halves to reduce the transpiration. In addition, they were placed in the shade in the College nursery and watered from time to time.

Inarching. Care was taken to match the size of the stem of the year-old stock with a branch from the selected trees to serve as the scion. The two were put together by making insicions on both the stock and the scion approximately seven centimeters long, removing about one-half of the stems to give them a good fit, and making sure that the cambium layers of the two coincided as much as possible. The two were then tied with a piece of fine cotton twine, care being taken that the fitting was tight. When the scion was from a low branching tree, no support was necessary and the stock was placed on the ground. In many cases, however, it was necessary to place the stock on a support or to tie it to a conveniently located branch of the tree. Pieces of thin cardboard inscribed with India ink and soaked in paraffin were used as labels.

The stocks were watered whenever necessary until they were severed, giving them ordinary protection against disturbances. After being severed from the mother trees, the inarched plants were kept under partial shade in the Agronomy nursery. The stock was lopped at the point just above the union, at the same time cutting the part of the scion below this point. The cut surfaces were made smooth and painted with a mixture of three parts kerosene and one part asphalt, grade D. The leaves of the inarches were pruned by removing half of each leaf. The inarches were carefully attended to until they were well established and necessary records were taken.

Shield budding. In this experiment the inverted "T" method was used in the manner described by Gonzalez (1925).

Two methods of tying the tape were employed. In the first method the buds were completely covered while, in the second method, the "eyes" of the buds were left exposed in wrapping, the opening being limited to the minimum.

Cleft grafting. The method used was also the same as that described by Gonzalez (1925). The moss was moistened from time to time, generally twice a week. After three to four weeks the covering was removed gradually.

EXPERIMENT AND RESULTS

Details and results of the experiment in marcotting the star apple are presented in tables 1, 2, and 3. The attempt to determine the approximate days needed for rooting was not successful as it soon became evident that even intermittent opening of the covering had an apparent adverse effect on rooting; and when the interval was prolonged, roots had already formed in some.

After 156 days, those that rooted had their roots well out of the coconut husk, and those without roots did not root at all. In this latter case the ringed portion formed new bark again.

For results in inarching, table 4 may be consulted.

Data on shield budding as affected by season, age of budwood, preparation of shield buds, and methods of tying the buds are not presented in detail as the results were all negative.

The effects on the success in cleft grafting of the age of the scion and of immediate or delayed insertion and previous defoliation of the budwood two weeks before grafting are shown in table 5.

DISCUSSION OF RESULTS

Marcottage

Out of a total of 180 marcots prepared, 49, or a percentage of 27.2, rooted. When they were separated, into groups according to size of branches, however, results were significantly different.

The highest per cent of success was obtained from the group composed of small branches, followed by the medium, and was lowest for the large branches, values being 46.7 ± 3.0, 25.00 ± 1.9, and 10.00 ± 0.0 per cent respectively (table 1). The difference between that of the small and the medium is significant and more so between any of the first two groups compared with the large branches.

Delaying the covering of the ringed branches by 10 days proved to be favorable to rooting (table 2). For small branches, the percentage of successful marcots when immediately covered was 40.0 ± 3.9, but when covering was delayed it was 53.3 ± 4.4. The difference is not significant, but it tends to corroborate the significant differences obtained from the medium and the large branches as a consequence of delaying covering of the marcots. For the medium sized branches the values were: immediately covered, 16.7 ± 2.2; delayed covering, 33.3 ± 2.2; and for large branches immediately covered, 3.3 ± 2.2; and delayed, 16.7 ± 2.2.

Treatment with a 40-unit Hormodin water solution for 24 hours did not give any significant result when compared with the branches that were not treated (table 3). Neither did the 20-unit Hormodin water solution nor the Auxilin water solution prepared according to dilution number 3 give a favorable result.

Inarching

A very satisfactory and almost uniform result was obtained from inarching one year old star apple seedlings. From 85 to 100 per cent of the inarched plants united and lived. After 60 days the plants were well united with the scions and were all ready to be severed from the parent trees. The earliest time the inarched plants could be separated from the parent tree was later proved to be 20 days (table 4).

Shield budding

Out of 360 buds from different ages of budwoods—shield buds with and without wood and completely and partially covered shield buds—not a single one proved successful. In only one case did the shield unite, but it did not grow, for the shoot fell off resulting in a blind bud. Gonzalez (1934), in his previous experiment, obtained a similar discouraging result.

Cleft grafting

For use in cleft grafting, young scions proved the poorest with medium and old branches giving significantly higher percentage of living grafts.

When scions were inserted in the stocks soon after being gathered, the medium aged branches gave a significantly higher percentage of success (average of 70.0 ± 3.9) than did either old (26.7 ± 2.2) or young (6.7 ± 2.2) (table 5).

When the scions were kept in moist sand for one week before they were used for grafting, the old ones proved the best. Values obtained were 80.0 ± 3.9, 40.0 ± 3.9, and 0 per cent for old, medium, and young scions, respectively. The difference is significant.

When the scions were defoliated two weeks before insertion the old ones also gave the highest number of living grafts, although the difference between this and the medium was not significant. Computed on the basis of three sets of the experiments, averages are: old 90.0 ± 0.0, medium 83.3 ± 2.2, and young 40.0 ± 3.9.

Compared on the basis of treatments given to the scions, defoliation two weeks before grafting proved the best. In the young scion group the difference between defoliation and the other two treatments is highly significant. In the medium aged scions, defoliation also resulted in an increase in successful grafts although the difference between this and the immediately inserted group is hardly significant, values being 83.3 ± 2.2 and 70.0 ± 3.9, respectively. For the old scions the defoliated group was also the highest, but the increase above that of the next ranking group kept in sand for one week is not significant (90.0 ± 0.0 vs. 80.0 ± 3.9).

SUMMARY AND CONCLUSION

1. The star apple responds favorably to propagation by marcottage, inarching, and cleft grafting. Shield budding was not successful.

2. Out of 180 marcots prepared from branches of different sizes, 40, or a percentage of 27.2, rooted. Grouped according to size of branches used, the small ones gave an average percentage of 46.7 ± 3.0, medium 25.0 ± 1.9, and large 10.0 ± 0.0.

3. Delaying the covering of the ringed branches for 10 days was found favorable to rooting in the marcottage of star apple although the increase obtained for the small branch group was not significant.

4. Previous treatment of the ringed branches with 40- and 20-unit Hormodin and Auxilin water solutions (dilution No. 3) for 24 hours gave no advantage over the untreated branches in marcotting the star apple.

5. Inarching 390 seedlings gave a success of from 85 to 100 per cent. Twenty days after inarching was found to be the earliest time that the inarches could be separated from the parent tree.

6. Regardless of the season, not one of the 360 buds from different budwoods and with different treatments succeeded in growing on the stock.

7. For use in cleft grafting, young scions proved the poorest, with medium and old scions giving significantly higher percentage of living grafts.

8. When scions were inserted in the stocks soon after gathering, the medium aged branches gave a significantly higher percentage of success (average, 70.0 ± 3.9) than did either the old or young scions.

9. When the scions were kept in moist sand for one week before insertion, the old ones proved the best, giving an average of 80.0 ± 3.9 per cent success.

10. When the scions were defoliated two weeks before insertion, the old and the medium ones gave high percentages of success, being 90.0 ± 0.0 and 83.3 ± 2.2, respectively.

11. Defoliation for two weeks before grafting proved better than non-defoliation and keeping them in sand one week before grafting.

12. For simplicity of technique and reliability of result, inarching is highly recommended for the star apple.

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TABLE 1

The influence of size of branches on percentage of success in marcotting star apple

SIZE OF BRANCHES	DATE OF RINGING	APPROXIMATE DATE OF FIRST ROOT FORMATION	DATE WHEN MARCOTS WERE OPENED	TOTAL NUMBER OF BRANCHES USED	AVERAGE PERCENTAGE OF SUCCESS
Small (about 2 cm. in diameter)	Sept. 10–15, 1938	Dec. 15, 1938	Feb. 12–16, 1939	60	46.7 ± 3.0
Medium (about 4 cm. in diameter)	Sept. 10–15, 1938	Jan. 12, 1939	Feb. 12–16, 1939	60	25.0 ± 1.9
Large (about 6 cm. in diameter)	Sept. 10–15, 1938	—	Feb. 12–16, 1939	60	10.0 ± 0.0

TABLE 2

The influence of 10-day exposure of the ringed portion on successful rooting in star apple marcots

SIZE OF BRANCHES	IMMEDIATELY COVERED WITH SOIL	EXPOSED FOR 10 DAYS BEFORE BEING COVERED WITH SOIL
	percentage of success	*percentage of success*
Small	40.0 ± 3.9	50.3 ± 4.5
Medium	16.7 ± 2.2	33.3 ± 2.2
Large	3.3 ± 2.2	16.7 ± 2.2

TABLE 3

The influence of auxin treatments on successful rooting in star apple marcots

TREATMENT	TREATED	UNTREATED
	percentage of success	*percentage of success*
20-unit Hormodin	30.0 ± 7.8	33.3 ± 12.0
40-unit Hormodin	23.3 ± 5.9	30.0 ± 7.8
Auxilin (dilution No. 3)	23.2 ± 5.9	23.3 ± 5.9

TABLE 4

Inarching one-year old star apple seedlings and severing them at different intervals

NUMBER OF PLANTS INARCHED	DAYS INTERVAL FROM INARCHING TO SEVERING	PERCENTAGE OF SUCCESS
30	10	0.0
30	20	100.0
30	30	100.0
30	40	100.0
30	50	100.0
60	60	91.7
60	90	91.7
60	120	91.7
60	150	95.0

TABLE 5

The influence of different treatments given to scions of different ages used in cleft grafting

TREATMENTS GIVEN TO SCIONS BEFORE INSERTION	YOUNG SCIONS	MEDIUM AGED SCIONS	OLD SCIONS
Inserted soon after gathering	6.7 ± 2.2	70. ± 3.9	26.7 ± 2.2
Kept in sand for one week	0.0 ± 0.0	40.0 ± 3.9	80.0 ± 3.9
Defoliated two weeks before insertion	40.0 ± 3.9	83.3 ± 2.2	90.0 ± 0.0

A COMPARATIVE STUDY OF CORN AND RICE BRAN AS CONSTITUENTS OF RATIONS FOR GROWING MARKET PIGS [1]

SALUEY EMASIRI

Rice bran and corn are the basal constituents of rations for growing pigs, being readily available in many parts of the Islands. Corn usually costs more than rice bran, but at times, when there is a shortage of palay, the price of rice bran becomes higher than corn, as it actually was at the time this experiment was started. Hence, the importance of modifying rations for pigs to keep the cost of production down to the minimum is evident.

Bautista (1918) found that rice bran was a more efficient feed for pigs than shelled corn, especially when they were on cowpea pasture.

Allas (1924), comparing the feeding value of corn and rice bran for pigs receiving camote soilage, concluded that rice bran was more efficient than corn for growing pigs.

Hughes and Mead (1922) obtained satisfactory results with rice by-products in combination with tankage and barley.

Smith (1936), citing the work of Dvoracheck and Fowler in which rice bran was compared with ground corn for fattening pigs in dry lot, concluded that rice bran was too bulky. Except for this fault, rice bran gave very good results. In that experiment tankage was used as protein supplement in the proportion of 9 to 10 per cent.

The object of this study was to compare the relative efficiency of rice bran and corn in rations for growing market pigs.

The experiment was started on November 21, 1936, and closed on June 19, 1937, covering a period of 210 days.

The work was conducted in the Department of Animal Husbandry, College of Agriculture.

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[1] Experiment Station contribution No. 1352. Prepared in the Department of Animal Husbandry under the direction of Assistant Professor Mariano Mondoñedo.

Animals used

Eighteen Berkjala weanling pigs, of which nine were castrated males and nine were gilts, were used in this experiment. The animals were fairly uniform in size and condition.

Feeds used

The feeds used were cracked corn, standard rice bran, copra meal, and dried shrimps. The chemical composition of these feeds as analyzed in the Department of Agricultural Chemistry is given below.

CONSTITUENTS	CORN	RICE BRAN	COPRA MEAL	SHRIMPS
	per cent	*per cent*	*per cent*	*per cent*
Moisture	12.48	9.20	10.51	14.55
Fat (ether extract)	4.91	13.89	5.30	2.61
Ash	1.54	10.11	9.50	19.73
Protein	9.37	12.38	16.28	55.61
Crude fiber	1.93	9.72	7.63	4.24
Carbohydrate (N.F.E.)	69.77	44.70	50.83	3.26
Calories per 100 grams	370.14	363.21	324.24	265.64

The proportions by weight of the feeds used in the feed mixture in each lot for the different periods were:

FIRST SEVENTY-DAY PERIOD

Lot	*I*	*II*	*III*
Corn	0.0	37.5	75.0
Rice bran	75.0	37.5	0.0
Copra meal	18.0	18.0	18.0
Shrimps	7.0	7.0	7.0
	100.0	100.0	100.0
N.R.[2]	1:4.4	1:5.0	1:5.6

SECOND SEVENTY-DAY PERIOD

Lot	*I*	*II*	*III*
Corn	0	40	80
Rice bran	80	40	0
Copra meal	16	16	16
Shrimps	4	4	4
	100	100	100
N.R.[2]	1:5.0	1:6.2	1:6.8

THIRD SEVENTY-DAY PERIOD

Lot	*I*	*II*	*III*
Corn	0	45	90
Rice bran	90	45	0
Copra meal	9	9	9
Shrimps	1	1	1
	100	100	100
N.R.[2]	1:6.5	1:7.4	1:8.3

To every 100 kilograms of the ration used, two kilograms of a mixture of common salt and corn cob charcoal were added.

Price of feeds

At the time this investigation was conducted, corn was worth 4.45 centavos a kilogram, rice bran 4.17 centavos, copra meal 4.50 centavos, dried shrimps 13.08 centavos, common salt, 1.31 centavos, and corn cob charcoal, 7.0 centavos.

The price of a kilogram of each of the feed mixtures used, based on the above prices, was:

	FIRST FEEDING PERIOD *centavos*	SECOND FEEDING PERIOD *centavos*	THIRD FEEDING PERIOD *centavos*
Feed mixture for lot I	4.85	5.58	4.29
Feed mixture for lot II	4.95	4.69	4.42
Feed mixture for lot III	5.06	4.80	4.54

Allotment of pigs

The pigs were divided into three lots of six pigs each, designated as lots I, II, and III. Care was taken to have the lots as uniform as possible with regard to sex, age, and condition of the pigs. As shown above, the pigs in lot I were given rice bran as the basal part of their rations; in lot II, equal parts of rice bran and corn; and in lot III, corn in place of rice bran. All the lots received copra meal and dried shrimps as protein supplement in the same proportion as prescribed in the College standard rations.

Feeding and management

Sufficient feeds to last one week were prepared each time; 5 kilograms of feed per 100 kilograms live weight of the animal a day were allowed during the first 70-day period; 4.5 kilograms, during the second 70-day period; and 3.5 kilograms, during the third 70-day period.

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[2] The nutritive ratios are based on a table of digestible nutrients of Philippine feeds, prepared by the Department of Animal Husbandry, College of Agriculture.

The pigs were fed twice daily, from 6:00 to 7:00 a. m., and from 3:00 to 4:00 p. m. They were given as much as they would consume.

Individual pigs were weighed weekly. For the initial weight of each pig, the average weights for three consecutive days were taken. The final weight was obtained in a similar manner. Weighing was done from 2:30 to 3:30 p. m. before the pigs received their afternoon meal. They were washed and allowed to dry before weighing.

All the lots were given the same care and treatment throughout the course of the investigation, the only point of difference being in the rations each lot received. During the first period, the pigs were driven out as one herd into a grass pasture after feeding. At noon they were driven into the hog house for watering and bathing. Camote soilage was given to them at this time at the rate of one per cent of the total live weight. Afterwards they were driven back to the pasture. In other words, the pigs were subjected to the grain-pasture-soilage system of feeding during the first seventy-day period.

During the second feeding period, all the pigs were kept in one-sixteenth-hectare inclosure bare of vegetation between meal times. In lieu of pasture, they received camote soilage as succulence. They were watered and bathed at noon as usual. The pigs were, therefore, under the grain-soilage system of feeding during this period.

During the third period, the pigs did not receive any kind of succulence either in the form of soilage or pasture. They were kept most of the time in their respective pens; that is, they were under the dry-lot system of feeding. At short intervals, they were allowed, however, to go out regularly for exercise into the runs adjoining their pens.

DISCUSSION OF RESULTS

First 70-day period. It may be noted in table 1 that lot I (rice bran) pigs made the largest amount of gain; lot II (corn-rice bran) pigs, second; and lot III (corn) pigs, the least. If the gain in weight of the pigs in lot I is taken as 100 per cent, lot II pigs gained 88 per cent, and lot III pigs, only 47 per cent. The pigs were about two to five months old at this time.

From the standpoint of feed needed to make a kilogram gain, lot I pigs required the least and lot III, the most. Since the nutritive ratio of the ration of lot III pigs was 1:5.6, which is wider than those called for in Evvard's (1:3.5-1:4.0) and Morrison's (1:4.0-1:4.5) standards for pigs, this result may be expected. Lot III pigs consumed the least amount of feed. Thus, corn in rations for these pigs was less palatable than the corresponding concentrates in lots I and II. Much time for chewing was spent by the pigs in this lot. Lot I pigs were the quickest to finish their feed.

On the basis of cost of feed needed to produce one kilogram gain, lot I pigs produced the cheapest gain, lot II pigs second, and lot III pigs the most expensive.

Second 70-day period. The same tendency as to daily gains made by the pigs in the previous period was observed during the second 70-day period. In this period, the pigs were about five to seven months old. The differences in gain between the lots, however, became less marked, indicating that as the pigs grew older, the corn rations became more suitable for them.

With the rate of gain of lot I pigs assumed to be 100 per cent, that of lot II was 90 per cent, and lot III, 65 per cent.

As to the amount of feed consumed per kilogram gain, the results showed marked improvement of the economy in feed in all lots, indicating better utilization of corn in the rations as the pigs became older. The difference between lots I and II is significant, while between lots II and III it is small.

Lot I pigs again made the cheapest gain, lot II pigs second, and lot III pigs the most expensive. At this time the cost of gain made by lot III pigs was only slightly more than that by lots I and II pigs, showing improvement in the feeding value of corn with older pigs.

Third 70-day period. During the last period, when the pigs were about eight to ten months of age, there was no difference between the average daily gain of the pigs of lots I and II. Lot III pigs still made the lowest gain. If the gain made by lot I pigs is taken as 100 per cent, lot II pigs made the same rate and lot III pigs 83 per cent.

From the point of view of feed consumed per kilogram gain, lot III pigs required the lowest amount, lot II pigs the highest, and lot I pigs intermediate. It is evident that corn is most efficient for pigs at this age.

The cost of feed consumed per kilogram gain was about the same in lots I and III and highest in lot II.

The entire 210-day period. The outstanding results obtained from the 210-day feeding trial showed that the highest rate of gain was made by pigs in lot I, followed closely by pigs in lot II, with those of lot III far behind (table 2). Expressed in percentage, with the gain of lot I pigs as 100 per cent, that made by lot II pigs was 93 per cent, and that by lot III pigs only 70 per cent.

As to the amount of feed needed to make a kilogram gain, lot I pigs required the smallest, lot II pigs second, and lot III pigs the largest.

From the standpoint of economy of gain, lot I pigs were the most economical, lot II pigs second, and lot III pigs the most expensive.

SUMMARY AND CONCLUSIONS

The relative efficiency of rice bran and corn was compared in an experiment on growing market pigs. These feeds were used as a basal part of rations with copra meal and shrimps as protein supplements. The feeding test was carried out in 210 days, divided into three periods of 70 days each.

For the entire 210-day period the rice bran lot made the most rapid gain followed by the corn-rice bran lot and the corn lot in the order named. When the rate of gain of the rice bran lot pigs is assumed to be 100 per cent, the rate of gain made by the rice bran-corn lot pigs was 93 per cent, and that by the corn lot pigs only 70 per cent.

To make a kilogram gain, the rice bran lot was the best, or 100 per cent, the rice bran-corn lot, second, or 89 per cent, and the corn lot, last, or 87 per cent.

From the standpoint of economy, a kilogram gain made by the rice bran lot pigs cost 20.73 centavos; that by the corn-rice bran lot pigs, 23.84 centavos; and that by the corn lot pigs, 25.14 centavos. The economy of gain made by the rice bran lot pigs was partly due to the low amount of feed required to make a kilogram gain in this lot and partly because rice bran, although higher in price than corn at the beginning of the experiment, on the whole was cheaper than corn.

It appeared that for young pigs, both from the standpoints of rate and economy of gain, the ration containing rice bran was more suitable than either that with corn alone or with corn and rice bran. The corn-rice bran lot stood intermediate between the rice bran and corn rations.

For fattening older pigs, corn as a basal part of the ration was better than rice bran in economy of gain. There was marked improvement in the feeding value of this grain with older pigs as shown by the rate of gain. It is advisable, therefore, to use rice bran as the basal constituent of rations when the object is to promote growth and development, and corn, when the aim is to fatten and finish pigs for the market.

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TABLE 1

Average results obtained in the first, second, and third seventy-day periods of the experiment

ITEMS	LOT I RICE BRAN	LOT II CORN-RICE BRAN	LOT III CORN
First seventy-day period			
Daily gain per pig in kgm.	0.17	0.15	0.08
Daily ration per pig in kgm.	0.72	0.75	0.63
Daily ration per 100 kgm. live weight in kgm.	4.12	4.23	4.27
Feed consumed per kgm. gain in kgm.	4.33	5.09	7.90
Feed cost per kgm. gain in centavos	21.00	25.20	39.97
Second seventy-day period			
Daily gain per pig in kgm.	0.29	0.26	0.19
Daily ration per pig in kgm.	1.17	1.24	0.91
Daily ration per 100 kgm. live weight in kgm.	3.51	3.86	3.77
Feed consumed per kgm. gain in kgm.	4.09	4.71	4.85
Feed cost per kgm. gain in centavos	18.73	22.09	23.28
Third seventy-day period			
Daily gain per pig in kgm.	0.35	0.35	0.29
Daily ration per pig in kgm.	1.83	1.95	1.44
Daily ration per 100 kgm. live weight in kgm.	3.28	3.63	3.52
Feed consumed per kgm. gain in kgm.	5.18	5.56	4.91
Feed cost per kgm. gain in centavos	22.22	24.57	22.29

TABLE 2

Average results obtained in the entire feeding trial of 210 days

	LOT I	LOT II	LOT III
Initial weight per pig in kgm.	11.63	12.57	11.98
Final weight per pig in kgm.	68.17	66.00	51.18
Daily gain per pig in kgm.	0.27	0.25	0.19
Daily ration per pig in kgm.	1.24	1.31	0.99
Daily ration per 100 kgm. live weight in kgm.	3.10	3.33	3.13
Feed per kgm. gain in kgm.	4.62	5.18	5.32
Feed cost per kgm. gain in centavos	20.74	23.84	25.14

PUBLISHED CONTRIBUTIONS OF THE COLLEGE OF AGRICULTURE: XVII[1]

L. B. UICHANCO
Dean, College of Agriculture

On Loyalty Day, October 10, 1939, when the thirtieth anniversary of the College of Agriculture was celebrated, "A Handbook of Philippine Agriculture" was published. This *Handbook* embodies the pooled efforts of the technical personnel of the College, and the task of amassing and coördinating the enormous amount of data and information of use to the Philippine farm practitioner entailed major demands on their time and energy during the greater part of the academic year. After all the material had been garnered, largely from the accumulated results of investigation in the College itself, the next problem was to keep the volume within a reasonable size for convenient reference. Even after the elimination of many pages of copy, the result was a book of over eight hundred pages.

Although much of it was in the nature of a compilation of already published data, the work that went into the preparation of the *Handbook* gave the members of the faculty of the College an excellent opportunity to look back and reëstablish their research bearings in the field of Philippine agriculture. It gave them a chance further to appraise critically the scientific record of their own institution, determine where it had been amiss in seeking satisfactory answers to important questions confronting the farmer, and see therein a challenge to themselves as original investigators. If the publication of this *Handbook* has done nothing more than accomplish this purpose, it has justified itself amply. The numerous letters of commendation constantly received from our colleagues in the government agricultural service, from practical farmers, from educational institutions and experiment stations, local and foreign, and from other sources have indeed encouraged us to believe that the book fills a distinct need and that our efforts in producing it have not been in vain.

Below is the customary annual inventory of the regular published contributions of the College for the year. Many of the research activities have been exploratory in scope, although not a few of the titles imply a continuation of a long-range program of investigation. Among those in the latter category may be mentioned the experiments on feeds of animals, fertilizer requirements of various plant crops on different soil media, costs of producing livestock and plant products, adaptability of breeds of domestic animals to tropical conditions, improvement of farm practices and tools, finding new and better strains of field crops, fruits and vegetables, nutrition problems of the Filipino, control of plant pests and diseases, and the like. The equipment and personnel of the College do not permit follow-up experiments on more impressive dimensions. Because large-scale work is best left to commercial or semi-commercial concerns, further amplification on the part of this College is neither feasible nor desirable. The most important rôle of this institution, and the one in which it has shown its worth from the beginning, is to produce within the smaller confines of its research laboratories and trial fields original results that are capable of more extensive development elsewhere. Thus, a much larger number of the basic problems can be adequately attended to than would be possible otherwise. True it is that in the pursuit of these investigations, errors of fact or interpretation have been inadvertently committed, some of them serious, owing inherently in part to the small-scale nature of the experiments. But the most valuable asset of the College is that research is constantly kept very much alive, and if there have been mistakes, we have not hesitated to recognize them as such, and either correct them or, failing this, profit by them to improve future work.

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[1] General contribution No. 737. For earlier contribution lists, see previous volumes of this journal.

II. EXPERIMENT STATION CONTRIBUTIONS

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(1297) MONDOÑEDO, MARIANO. 1939. Cost of producing pigs at the College of Agriculture. The Philippine Agriculturist 28: 25–37.

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(1299) EAMIGUEL, PEDRO G. 1939. Self-feeding free choice vs. self-feeding no choice systems of feeding corn, rice bran, copra meal, and fish meal for market pigs. The Philippine Agriculturist 28: 52-61.

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(1303) Aquino, D. I., and Ambrosio L. Madamba. A study of root nodule bacteria of certain leguminous plants. The Philippine Agriculturist 28: 120–132. *2 text-fig.*

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(1306) Fronda, F.M., and Engracio Basio. 1939. Ducks in battery laying cages. The Philippine Agriculturist 28: 152–157.

(1307) Mercado, Toribio. 1939. Construction and improvement of cassava graters in the College of Agriculture. The Philippine Agriculturist 28: 158–161. *1 text-fig.*

(1308) Capinpin, I. M., and Ian Khambanonda. 1939. Studies on the cytology and cross-compatibility of some cotton varieties. The Philippine Agriculturist 28: 163–186. *4 pl.* and *1 diagram.*

(1309) Manresa, Miguel and Prudencio Falcon. 1939. Hematological studies on cattle: III. Fluctuations in the hemoglobin of Indian Nellore oxen as affected by seasonal variation. The Philippine Agriculturist 28: 187–205. *4 charts.*

(1310) Estioko, Roman P. 1939. Weather observations at the College of Agriculture, 1924-1937. The Philippine Agriculturist 28: 206-224. *2 charts.*

(1311) de Leon, A. I., and Felipe T. Agdeppa. 1939. Hydrogenation of mixed oils. The Philippine Agriculturist 28: 225–242.

(1312) Luna, Jose G. 1939. Protein supplements in poultry rations. The Philippine Agriculturist 28: 243–250.

(1313) Villegas, Valente. 1939. The birth weights of horses, cattle and carabaos and their relation to the weights of dam. The Philippine Agriculturist 28: 253–259.

(1314) Espino, Rafael B. 1939. Studies on the fertilizing value of Mayon Volcano ash: II. Beneficial effects of adding ammonium sulfate. The Philippine Agriculturist 28: 260–270. *6 text-fig.*

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(1317) Mercado, Toribio. 1939. A comparative study of two bud sports of cassava and their parent varieties. The Philippine Agriculturist 28: 308–320.

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(1319) Viado, G. B. 1939. External anatomy and diagnostic characters of some common Philippine white grubs. The Philippine Agriculturist 28: 339–410. *Pl. 1–10.*

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(1321) Mabbun, P. N. 1939. Farm costs and practices of a twenty-hectare coconut plantation in Laguna province. The Philippine Agriculturist 28: 452–478.

(1322) Capinpin, J. M., and Aniceto O. Rollan. 1939. Hybrid vigor in the first generation crosses between strains of Cebu corn. The Philippine Agriculturist 28: 491–503.

(1323) Babaran, Jose M. 1939. Pasture weeds and cost of removing them by cutting. The Philippine Agriculturist 28: 504–520.

(1324) Teodoro, A. L., and Mariano A. Perlas. 1939. How efficient is a vacumatic gas saver? Natural and Applied Science Bulletin. 7 (2) 185–193.

(1325) Fronda, F. M., and Andres M. de la Cruz. 1939. Studies on the physical qualities of the hen's egg: VII. Variability of the physical qualities of new-laid eggs produced in different laying periods. The Philippine Agriculturist 28: 523–542.

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(1329) Asuncion, Pedro P. 1939. A comparative study on the forage and water consumption of sheep and goats. The Philippine Agriculturist 28: 576–582.

(1330) Calma, Valeriano C. 1939. Studies on different containers for potting fruit-plants. The Philippine Agriculturist **28**: 583–592. *2 text-fig.*

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(1333) Cendaña, S. M., and D. V. Fermin. 1940. Biology of Kaloula picta (Duméril et Bibron) with special reference to its development and breeding habits. The Philippine Agriculturist **28**: 626–656. *Pl. 1., 1 text-fig., 5 charts.*

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(1345) **Huertas, Angel S.** 1940. A study of the yield of cassava as affected by the age of cuttings. The Philippine Agriculturist 28: 762–770.

(1346) **Ricerra, Fernando C.** 1940. Observations on the capacity and measurements of the alimentary tract of native carabaos. The Philippine Agriculturist 28: 771–778.

(1347) **Mendiola, N. B.** 1940. Introduction of tsampedak and suspected case of natural hybridization in Artocarpus. The Philippine Agriculturist 28: 789–796.

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III. GENERAL CONTRIBUTIONS

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(681) **Villegas, Valente.** 1939. Travel notes on oriental neighbors. The Philippine Agriculturist 28: 62–68.

(682) **Uichanco, L. B.** 1939. In memoriam: Emma Sarepta Yule. The Philippine Agriculturist 28: 69–70.

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IV. MISCELLANEOUS CONTRIBUTIONS

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COLLEGE AND ALUMNI NOTES

Miss Helen F. Topping, who as a missionary in Japan has been associated with Dr. Kagawa, the famous leader of the Japanese coöperative movement, and who has visited and studied the coöperative organizations in Sweden, Denmark, and France spoke on coöperatives before the faculty and students of the College on January 23.

For the eleventh consecutive year, Unit III composed of the Los Baños Colleges won the championship in the annual University of the Philippines intramural track and field meet held at the Rizal Memorial Track-Football stadium on January 27-28. The winning Los Baños unit earned a total of 98 points; Unit II, representing the Colleges of Liberal Arts, Education, Business Administration, Fine Arts, U. P. High School, and Conservatory of Music, finished second with 41 points; and Unit I, composed of the Colleges of Engineering, Law, Medicine, and Veterinary Science, third with 12 points.

The first Laguna Boy Scout Rally was held on the College Campus on January 28 in connection with the celebration of the tenth anniversary of scouting in the College of Agriculture. The program for the day started with a field mass on the grounds of the Little Flower Chapel followed by field events held on the College Campus. Various troops of the province participated in these. Lunch was served the scouters at Molawin Hall. After a short rest, a program was presented by the local troop at Baker Hall aided by the Campus Cub Scout organization and Camp Fire Girls. Dean L. B. Uichanco was elected President of the Laguna Council succeeding President B. M. Gonzalez. Closing remarks were made by retiring President Gonzalez and Chief Scout Executive, E. Villacorta.

Doctor G. O. Ocfemia, Associate Professor and Head, Department of Plant Pathology, becomes the Managing Editor of *The Philippine Agriculturist* beginning with the June number of the Journal.

At a regular meeting of the Los Baños Biological Club on January 25, the following paper was read:

Statistical interpretation of experimental results in biological and agricultural research by Dr. José M. Capinpin.

Professor Edward A. White of Cornell University was guest of honor at a dinner tendered by local Cornellians, heads of departments of instruction, and officers of the Los Baños Biological Club at Molawin Hall on February 13. Professor White was guest speaker at a special meeting of the Club immediately following the dinner. He spoke on orchids.

Dr. Candido M. Africa, professor and head, Department of Parasitology, Institute of Hygiene, University of the Philippines, spoke on random thoughts on science and scientists at the fourteenth initiation exercises of the Society for Advancement of Research on February 15.

Professor Jesús Patiño Navarrete of the School of Agriculture, University of Mexico, was a campus visitor on February 15. In company with Dean Uichanco, he visited the various departments of the College.

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